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THE HAWAIIAN
PLANTERS' RECORD

Volume XXVII. JANUARY, 1923 Number 1

A quarterly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

Cane Varieties: An Acreage Census

The cane variety, H109, now covers more than 52,000 acres. The Lahaina cane, formerly occupying 76,000 acres (1913 census), now holds but 13,500 acres, there being 8,500 in the 1923 crop, and about 5,000 in the 1924 crop. The 52,000 acres of H109 are divided between the two coming crops, with 23,000 acres for 1923 and 29,000 for 1924.

Yellow Caledonia shows a decrease of some 5,000 acres since last year, there being 94,000 as against 99,000 a year ago. The Yellow Caledonia area for 1923 is 49,000; the 1924 area is 45,000.

The areas of D1135, Striped Tip and Yellow Tip are substantially the same as last year. Lower areas are reported for D117, Rose Bamboo and H146.

Badila takes its place among the varieties occupying more than a thousand acres of land, and Yellow Bamboo no longer holds this distinction.

Higher Yields per Acre

That tropical agriculture is going to take full account of the possibilities of lowering costs of production by increasing yields per acre is plainly indicated, by "Some Notes on Rubber Estates of the Future," which we reproduce in this issue.

Individual rubber trees vary enormously in yield. By selecting and propagating the better ones through grafting, it is predicted that a very substantial increase in yield will result. With this matter of tree selection is also considered that of soil selection, which refers to choosing those areas best adapted to high yields. On these two points the average yield, it is claimed, can be more than doubled, and losses converted into substantial profits even at low prices of rubber.

Permanent Agriculture

The question is frequently asked: How long can Hawaiian soils hold out under intensive fertilization and extremely heavy cropping of some of our irrigated fields? To what extent can this question be answered by the Rothamsted Experiments?

Systematic field experiments were started at Rothamsted (Harpenden, Herts, England) in 1843, and investigations have been continued for seventy-nine years. "The great object," as A. D. Hall, a former director of the work, wrote, "is to obtain knowledge that is true everywhere, and to arrive at principles of general application, leaving the farmer himself, through his more immediate advisors, to adopt these principles to his own practical conditions and translate them into pounds, shillings, and pence. Thus the farmer who visits Rothamsted must not expect to see demonstrations of the most profitable means of growing this or that crop, but rather to obtain information as to its habits and requirements which, on reflection, he can make useful under his own conditions."

Having long had the desire to discuss the Hawaiian agriculture of today with the authorities at the Rothamsted Experiment Station, we asked Mr. Muir of this Station, now in England, to represent us in interviewing Dr. E. J. Russell, the present director. We furnished the following memoranda:

A point of great interest to us, on which the Rothamsted investigations might throw some light, is whether we can have "permanent agriculture" under our intensive and continuous one-crop system of cane cultivation. Take the Waipio substation results as a basis of discussion. These fields have been under cultivation about 30 or 35 years. During this time the amount of organic refuse returned to the soil has been so little as to be negligible.

These fields were taken over by us for experimental purposes in 1912. Prior to this time they had produced about 8 tons of sugar every two years, say 60 tons of cane (cane leaves, etc., all burned, would amount to several tons more). Our experiments have been along commercial lines, that of perfecting the present intensive agriculture based on chemical fertilization and irrigation. We have gradually increased the yields to 13, 14, and 15 tons of sugar per acre. Almost every crop to date has been a little better than the last. Particularly is this true when you consider both the elements of area and time. We learn, for instance, that two years is not the optimum cropping period; that while this gives the largest yield per acre, it does not give the largest yield per-acre-per-month. On a 15½ months' crop, taken off last August, we got 10.23 tons of sugar, which is 0.66 ton-of-sugar-per-acre-per-month. This is the best to date, as the two-year equivalent would be 15.84. Ewa Plantation has reported four fields this year with yields of over 15 tons. These big yields result from:

1. Control of insect pests by parasites.
2. Suitable cane variety, having resistance to various diseases.
3. Adequate irrigation throughout the growing period.
4. Ascertaining the profitable limit of chemical nitrogen and applying it. (Also phosphoric acid and potash where field tests show it to be needed.)
5. Allowing about 10 to 12 months to elapse between the last application of nitrogenous salts and time of harvesting. (This is to improve sugar content of cane.)
6. Allowing two to three months between last irrigation and time of harvest. (This also causes sugar content to improve.)

We find it profitable to apply 300 or even 350 pounds of nitrogen to a two-year crop. Chemical examination of the soils at Ewa shows no ill effects to have resulted from heavy use of nitrate of soda year after year. If it becomes advisable to use sulphate of ammonia to offset the effects of nitrate of soda, we could do so, or we could, if necessary, turn to nitrate of ammonia.

The point is, can we continue to raise big crops for years and years from chemical fertilizers (barring increase of insects and disease, which is beside the point under discussion)? Are we depleting the organic matter of the soil and altering its water-holding capacity, or are we actually maintaining this or perhaps increasing it by producing huge root systems year after year with chemical nitrogen, these, on decaying, adding to the organic matter of the soil itself?

Rothamsted experiments tell of maintaining yield by chemical nitrogen to an extent that is equal to, if not greater than, what is done by continuous applications of barnyard manure.

With wheat and other grain crops we are told that the cost of the chemical nitrogen necessary to do this is prohibitive from a commercial standpoint. With sugar, this is not the case. Three hundred pounds of nitrogen at 20 cents per pound costs $60.00, which amounts to only $5.00 per ton on a 12-ton crop.

This being the case, is not our agriculture sound and "permanent" from the standpoint of the Rothamsted work dealing with the maintenance of yields through chemicals only?

We are in receipt of a letter from Mr. Muir, December 5, 1922, in which he tells us of the opinion expressed on this intensive sugar agriculture, considered in the light of nearly eighty years of investigations dealing with chemical fertilizers in their effects upon the soils and crops of England, those investigations including extensive comparisons between chemical and organic manures. Mr. Muir writes:

I paid a visit to Rothamsted about ten weeks ago and had a long talk with Dr. Russell. He was surprised to hear that you were using nitrate of soda without it showing any ill effect, he expected you were using nitrate of ammonia. He was also surprised that so little of the green crop had been returned to the soil on many of the plantations. *But he said, after* considering these points, that there was no evidence to be drawn from any of their work at Harpenden that indicated that our methods were not along the lines of permanent agriculture.

The Java Sugar Cane Leaf-Mite in Hawaii.

By O. H. Swezey.

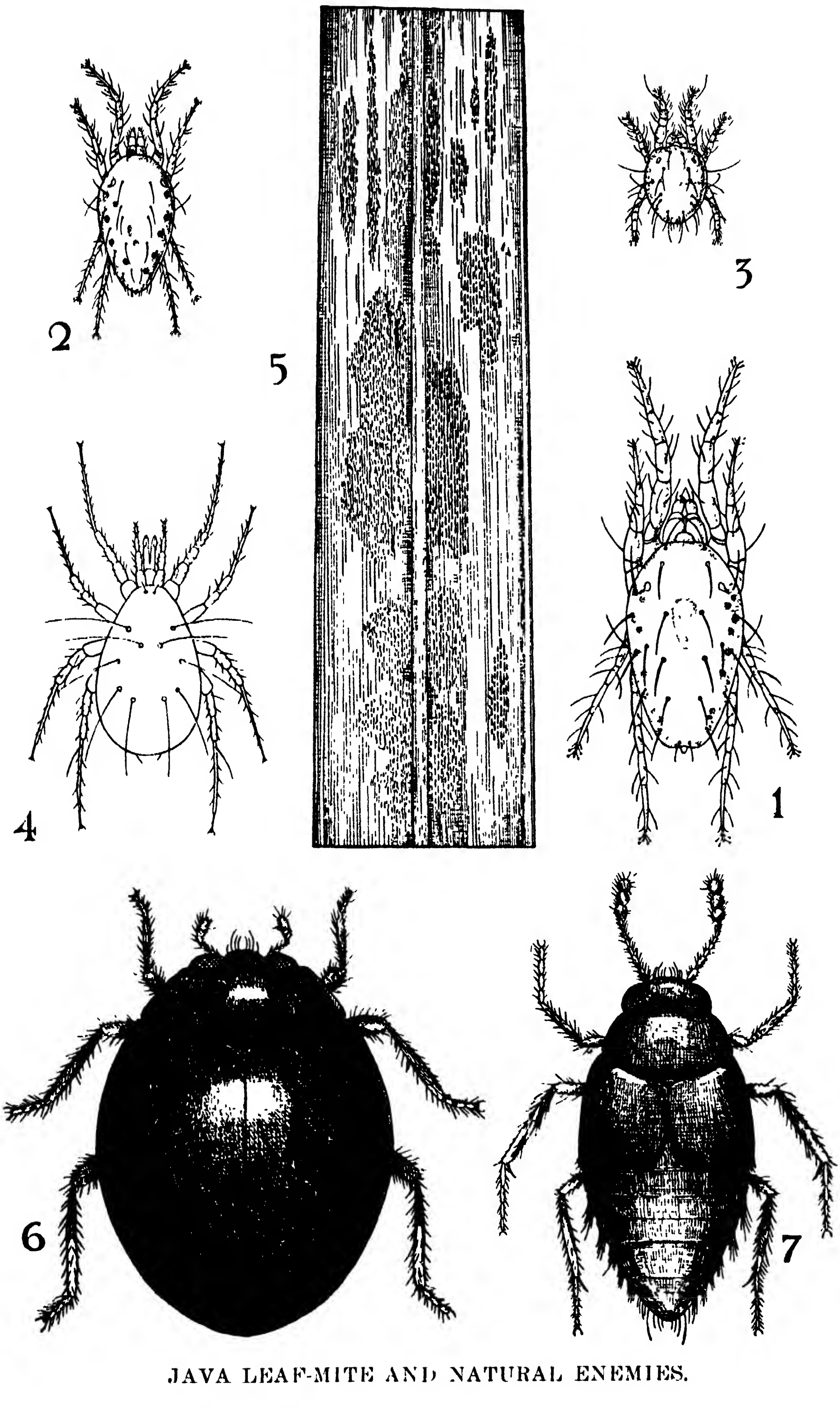
A very large infestation by the Java sugar cane leaf-mite occurred in an area of plant cane on the plantation of the Oahu Sugar Company during the summer of 1922.

The presence of this extensive infestation was first made known by Dr. L. O. Kunkel in August, when he examined conditions where the cane was not maintaining a healthy appearance. In September and October, I made several trips with him to the region, making observations on the conditions, and trying an experimental dusting to kill the mites.

The infested area included fields 43, 44, 45, 46 (partially), 47 and 49, altogether comprising about one thousand acres, being situated in the region between Kipapa Gulch and Waikakalaua Gulch, and at an elevation running from about 400 to 550 feet. It is planted chiefly to H109 cane, though there is also some D1135 and H456. The planting occurred in the various fields during April to July. The method of planting was by means of furrows opened between the old cane rows, instead of the ground having been first plowed. The previous ratoons were Lahaina, some stools of which came up between the rows of the newly-planted cane.

At the time when first noted the mites were very numerous, occurring on the underside of the lower leaves and causing them to become yellowish streaked longitudinally. Older infested leaves had become reddish in streaks; and still older ones were drying up and dying, at edges and tips first. The infestation was practically all over this one thousand acres, though in places it seemed to have passed already, evidences showing on the leaves where the mites had previously been abundant. Where the cane seemed to have been thriving on account of favorable conditions, there was apparently no special detrimental effect by the mites. In some places where on account of weeds, the condition of the ground due to method of planting, or possibly being too dry (in the hot, dry summer and perhaps not always irrigated sufficiently or frequently enough), or other less favorable conditions, the effect on the cane by the mites was more conspicuous, apparently for a time checking the growth of the cane. The cane has been improving well after some rainy weather, and the disappearance of the mites.

This leaf-mite is very small and difficult to see except with a magnifying glass, though where numerous on a leaf and viewed *en masse* their presence is readily distinguished. A heavily infested leaf may have many thousands of them in all stages of growth and eggs as well. The latter are tiny, globular, white objects placed on the under-side, usually scattered all along near the mid-rib. The mites themselves are greyish-yellow in color, with some dark spots laterally placed on the back of the abdomen, and towards the front of the abdomen are two red spots, one towards each side. They feed by puncturing the leaf and sucking out the juice, sometimes removing the chlorophyll as well, which gives a greenish color to these mites.



JAVA LEAF-MITE AND NATURAL ENEMIES.

1. Female leafmite, × 80.
2. Male leafmite, × 80.
3. Young leafmite, × 80.
4. A predacious mite, × 60.
5. Cane leaf injured by leafmites, × ½.
6. A ladybeetle (*Stethorus vagans*), × 40.
7. A Staphylinid beetle (*Oligota* sp.), × 45.

4, 6, 7. Enemies of the leafmite.

So far as I can learn this mite has not been previously recorded here in Hawaii. We have been accustomed to finding it now and then on the cane leaves in various plantations of the Islands, but never in such extensive infestations as to give attention to it, and apparently no one previously has determined it. By reference to a description and an account of its occurrence in Java, respectively in *Mededeelingen van het Proefstation Oost-Java*, n.ser. No. 37, p. 48, 1897, and *Handbook voor de Suikerriet-Cultuur en de Rietsuiker-Fabricage op Java*, pp. 282-291, Pl. 39, 1906, I am able to identify it as the same. In the first publication cited, Zehntner describes this mite under the name *Tetranychus exsiccator*. In the second publication cited, Van Deventer gives a more complete account of the mite and the insects which prey upon it. The colored plate is specially helpful in enabling one to identify the mite, as the description is rather brief.

Another species of leaf-mite, *Paratetranychus viridis*, occurs on cane leaves in Porto Rico, affecting them similarly to what the Java species does. It is only prevalent at times of drought.

At the time of the extensive infestation at Oahu Sugar Company, there were a few of the mites to be found on the cane at the Experiment Station grounds. and in fields on other plantations that happened to be visited during the time, They were conspicuously abundant in ratoon cane of field 12, Oahu Sugar Company, in a corner of the field in the shelter of the ironwood trees along the government road. Evidence of recent occurrence was also found on Lahaina cane of 1923 crop in field 52 mauka of the main infested area.

On September 29, we tried some dusting experiments on the mite in field 47, using tobacco dust, and nicodust. Examining for results on October 3, it was found that there had been little, if any, effect on the mites. There were less of them in the cane that had been treated, but in untreated cane they were also fewer in numbers. They were being preyed on by several natural enemies and seemed to be very much on the wane. When the region was visited again on October 24, the mites had almost entirely disappeared. It was very difficult to find any living mites anywhere in the whole area. This disappearance was probably due to the natural enemies, though it is difficult to say for sure, and it is impossible to account for it in any other way, though some heavy rains that occurred may have had something to do with it also.

The principal natural enemy observed in the field was a predacious mite larger than the leaf-mite and very active, which increased in abundance at the time the others were decreasing but finally disappeared itself when the leaf-mites were gone. The species of this predacious mite has not been determined.

Another enemy of the leaf-mite was a very small, black ladybeetle (*Stethorus vagans*) which commonly feeds on other species of leaf-mites usually called red spiders. Both the larvae and adults of this ladybeetle feed on the leaf-mites and each individual could eat a great number of the mites and probably their eggs also.

Still another leaf-mite enemy present was a minute Staphylinid beetle. The species is undetermined, but it may be *Oligota oviformis*, which feeds on red spiders in California. It is brown, and its larvae are whitish. Both feed on the mites and their eggs, eating great quantities of them.

It is a mystery how a pest of this kind, being wingless and able to spread only by crawling, could have become so widely spread in such a large area as one thousand acres all at the same time. There are two possibilities: If it were some pest that was on the seed cane when planted, it could be readily accounted for. But so far as we know the habits of this pest, we would not expect it to be present so generally on seed-cane, unless, perchance, it has some habit of depositing holdover eggs on or behind leafsheaths, which could have been left on the seed.

The more likely possibility is that they survived somehow from the ratoon crop previously on the field. Although the fields were burned in the usual manner for harvesting, I am told that, in some cases, it was not so thorough as could be desired. Then, due to the unusual method of planting, there was considerable growth from the old stools, and it may be that the mites or their eggs survived somehow in the old stools or in unburned trash, and that the shoots of cane from the old stools were first infested, then passing from these to the new plant.

Be that as it may, the infestation is over and finished with for the present, and whether it was specially connected with the method of planting employed may never be demonstrated; but the fact that such a large infestation (hitherto an unknown occurrence in Hawaii) occurred on this particular area makes it appear that, in some way, some phase of this procedure has favored the survival of the mites from some previous time when they must have been widely distributed though not numerous enough to be noted.

Their present sudden disappearance shows what can be expected should any such infestations occur in the future.

Ammonium Nitrate vs. Nitrate of Soda.

Waipio Experiment I. 2, 1922 Crop.

We harvested this year at Waipio an experiment in which equal amounts of nitrogen from ammonium nitrate and from nitrate of soda were compared. The cane was H109, first ratoons, 22¾ months old at harvest. The yields obtained were the same for both treatements, as shown below:

Treatment			Total Pounds Nitrogen	Yield Per Acre		
June 1920	Oct. 1920	Feb. 1921		Cane	Q. R.	Sugar
666 lbs. N. S.	667 lbs. N. S.	667 lbs. N. S.	310	113.3	8.29	13.67
666 lbs. N. S.	295 lbs. A. N.	295 lbs. A. N.	310	114.4	8.29	13.80

Ammonium nitrate is the more hygroscopic and takes up water rather readily in damp weather. That is a disadvantage. Other factors are in its favor. It is more concentrated, requiring much less material to supply the same amount of nitrogen. One hundred pounds of nitrogen are supplied by the following weights of material:

645 pounds of nitrate of soda.
488 pounds of sulfate of ammonium.
290 pounds of ammonium nitrate.

The nitrogen in ammonium nitrate is in the form of nitrate and of ammonia. Its use, then, would accomplish the same results as are obtained from the combined use of ammonium sulfate and of nitrate of soda. On Oahu quite a bit of ammonium nitrate has been used this year as spring dressing with what seemed to be satisfactory results.

The above discussion does not include consideration of the prices of these three materials. At the present time the price of ammonium nitrate is higher than that of nitrate of soda or ammonium sulfate. This prevents it from being an important source of nitrogen at this time.

J. A. V.

Report of the Committee on Juice Deterioration.*

By W. K. ORTH.

The very few who contributed to your committee's report did so handsomely, but to make the reading at all worth while the term "juice deterioration" had to be stretched a little, taking in what might, strictly considered, belong to cane deterioration.

Records are kept at Ewa of the purities, and lately also of the quality ratios, of all cane juices (first expressed juice) according to the number of days after burning the cane is ground. Two tables were compiled to show the effect of time elapsed on the qualities of the juice. In the first are shown the averages of all juices of the first, second, third, etc., day after burning, regardless of the individual fields they came from:

PURITIES OF CANE JUICES (CRUSHER) DAYS AFTER BURNING

DAYS—	1st	2nd	3rd	4th	5th	6th	7th	8th
January	85.6	85.0	84.7	84.3	84.2	84.6	83.4	83.4
February	84.9	85.9	85.1	84.7	83.1	82.6	81.5	81.4
March	87.4	87.3	85.8	84.9	84.4	84.5	82.1	80.7
April	85.8	88.8	88.6	88.7	86.8	...	...	...
May	88.8	88.0	87.6	87.5	86.7	...	...	...
June	88.0	86.9	86.6	86.2	85.3	84.8	...	...
July	86.2	85.3	84.0	85.1	84.4	85.1	83.9	...
Average	86.66	86.99	86.36	85.80	84.28	84.08	82.50	80.70
Drop in Purity.	...	.33	—.30	—.86	—2.38	—2.58	—4.16	—5.96
No. of Samples.	152	181	209	177	136	66	48	16

*Presented at the First Annual Meeting of the Association of Hawaiian Sugar Technogolists, Honolulu, November 15-18, 1922.

A second table shows the drop in purities and the change in the quality ratios from the first day after burning to the second, third and following days, for juices from individual fields:

Days After Burning.	Purity Drop.	Q. R. Change.	No. of Fields Sampled.
2	.5	+0.2	18
3	1.3	+0.2	18
4	1.3	+0.25	15
5	1.9	+0.4	12
6	2.3	+0.1	12
7	2.5	+0.3	8
8	2.5	+0.3	2
10	4.8	+0.6	3

These figures do not require much comment: nothing new is shown, but the wide range of the data should make them valuable. They again point to the necessity of having burnt cane through the mill as soon as possible.

A breakdown stopped the mill at Ewa for four days, with cane that had passed the first set of knives on the carrier, the yard well filled with cane on cars and a cut supply in the fields. When grinding again, the juice from the cane on the carrier had spoiled so much that it could not be clarified for analysis. The cane on the cars had apparently kept better than the cane in the field. The last juice of a certain field ground on the day of the breakdown had 85.5 purity; the cane on the cars during the first day of grinding again 85.0; and the cane in the field 83.6. The latter was then perhaps one-half to one day older than the cane on the cars.

MILL JUICES

Crusher Juice: Three tests of five hours' duration did not show any deterioration during the first three and only a very slight drop in purity at the end of the fifth hour. The initial purities ranged from 81.2 to 78.8 and after five hours from 81.2 to 78.2. No preservatives were used.

Last Mill Juice: Five tests on the last mill juice of Brix about 2.5 showed an average drop in purity during the first half hour of 1.9, at the end of the first hour 5.0, and at the end of the fifth hour 7.2, when no preservative was employed. With four drops of formalin per gallon, the figures were 0.5, 0.7, 3.7 respectively, indicating the necessity of a preservative and of frequent sampling of last mill juices.

Mixed Juice: Mr. H. Walker of Pioneer Mill Company writes:

Samples of mixed juice from the mill tank, kept in the laboratory in covered buckets, ordinarily lost from 0 to 0.2 polarization reading (dry lead method) in one hour. Samples of the first juice entering the scale tank on starting up the mill, after several

hours' shut down, lost from 0.2 to 0.5 in reading during the first hour and deteriorated a little more rapidly on standing longer. When the mill was washed down thoroughly and the mixed juice line flushed out with water just before starting up, the first runnings showed less tendency to deteriorate.

In order to get an idea of the effect of lack of cleanliness on the keeping qualities of juice, a five liter sample of mixed juice was divided into two portions, to one of which was added 25 cc of an actively fermented juice about 24 hours old. Both samples were allowed to stand in covered buckets in the laboratory and polarized at intervals. "A" is the untreated, and "B" the inoculated juice.

	At Once.	20 Min.	1 Hr.	4 Hrs.	8 Hrs.	18 Hrs.	22 Hrs.
"A" Reading	60.8	60.8	60.7	60.6	59.5	49.1	36.5
Percentage Lost on Original Reading ...	0	0	0.16	0.33	2.1	19.2	40.0
"B" Reading	60.5	60.4	60.35	59.75	57.9	27.7	11.2
Percentage Lost on Original Reading ...	0	0.16	0.25	1.0	4.3	54.2	81.5

While the inoculated juice went off about twice as fast as the other, very little change took place in either during the first hour. After 22 hours "A" contained 1.05%, "B" 1.20% glucose, an indication that glucose was used up as fast as formed.

The average time in transit from crusher to juice heaters is less than fifteen minutes. This is too short an interval for any appreciable deterioration, even in badly infected juice. Trash and juice allowed to accumulate around the mill may suffer an almost total loss of sucrose, but the proportion so lost of the total sucrose passing through the mill in very small.

For the same purpose, to trace the influence of cleanliness or the lack of it on the keeping qualities of juices, similar experiments to Walker's happened to be made at Ewa.

One portion of the juice samples, five gallons to start with, were infected with a small handful of cush-cush that had collected below the third mill rollers and was strongly sour—"B". The other portion was not so treated—"A".

	At Once.	30 Min.	1 Hr.	1½ Hrs.	2 Hrs.	2½ Hrs.	3½ Hrs.	4 Hrs.
Purity of "A"..	80.42	80.42	80.52	80.52	80.32	80.22	79.90	79.75
Drop in Purity..	....	....	* .10	* .10	.10	.20	.52	.67
Purity of "B"..	80.42	80.42	79.72	79.42	79.12	78.72	78.35	73.75
Drop in Purity..	....	....	.70	1.00	1.30	1.70	2.07	6.67

* Increase in purity.

In our case also, glucose did not increase but remained for four hours at 1.45%.

To test the possible argument that a destruction of sucrose might not be shown by figures based on polarization, on account of glucose being at first more actively fermented by zymase then the sucrose is inverted by invertase, a number of Clerget sucrose determinations were run which indicated that this is not the case and the results of the experiments seem indeed to show that no great deterioration takes place during the time the juice is in transit to the heaters.

However, this does not change our conviction that the greatest cleanliness around the mills is essential for highest recovery. The effect of the infection by fermented juice or sour cush-cush may not be strong enough to destroy sucrose in the inoculated juice during the short time of half an hour, yet the quantity of badly deteriorated material accumulating on the old apron conveyors and in the crevices and corners of some mills, which material from time to time is washed into the juice, is enough to lower appreciably the purity of the mixed juice below that what it should be. This we shall try to demonstrate by figures taken from records at Ewa.

The average differences between crusher juice and mixed juice purities for thirty-two weeks, taken from 1921 and 1922, records were:

First samples taken on Mondays	3.09
Average for Mondays	3.23
Mondays, after Sunday cleaning	3.60
Tuesdays	4.00

During fifteen weeks' grinding, with nine roller mill, with reduced chance of souring, the differences were:

Mondays	2.75
Tuesdays	2.75

But during twenty weeks following grinding with eighteen rolls:

Mondays	4.16
Tuesdays	4.53

This showing caused us to wash down the mill whenever we had a chance to do so and on quite a number of days we stopped the mill purposely to clean it with hot water. On such days the crusher-mixed juice difference was 2.07. On other days it was 3.07, which was the average of twenty-five samples.

We realize that at Ewa conditions have been severer than in many other places. The protracted grinding seasons of late years have prevented bringing the mills fully up to date in regard to cleanliness. That a step has been made in the right direction, by the installation of two Meinecke conveyors and steep sided more self-cleaning juice trays, is shown, to our mind, by the lessening of the crusher-mixed juice differences since part of our mill was thus equipped during the past season. While previously the difference was 4.78 (1921), 4.28 (1920), 3.65 (1919), it is now 2.80 with the same eighteen roller mill and about equal extraction.

With regard to preservation of mixed juice by means of either formalin, soda ash, or mercuric chloride, Mr. V. P. Iyer of Paauilo furnishes us with the results of a great number of carefully conducted experiments. The outcome is that formalin proved the most reliable, and soda ash, in combination or without lime, the least satisfactory.

HOT JUICES

Mr. Iyer made the experiments on a suggestion given us by Mr. N. King of Koloa, who found that soda ash proved in his case the cheapest and most effective preservative for hot juice kept over night in settling tanks. Mr. King gives the results of a test as follows:

Treatment.	Brix	Pol.	Purity	After 14 Hours. Brix	Pol.	Purity	Drop
Heavy liming and formalin	9.6	7.45	77.6	10.2	7.79	76.4	1.2
Heavy liming alone....	10.9	9.17	77.1	11.9	8.97	75.4	1.7
Heavy liming and soda ash, 1¾ lbs. per tank.	10.4	8.10	77.9	10.5	8.17	77.8	0.1

Mr. King continues: "Since the first of April we have been using soda ash in that capacity and find it highly satisfactory."

At Ewa we made experiments on the same lines with these results:

TREATMENT	TEMPERATURE	PURITY	DROP
Juice in settlers for 28 hours.			
Limed neutral to litmus + 10 lbs. soda ash for 7000 gallons........	In 212° F.	82.3	
Same	Out 161° F.	81.9	0.4
Limed neutral to litmus + formalin 1 part in 3500...............	In 212° F.	83.2	
Same	Out 161° F.	82.7	0.5
Limed neutral to litmus + 1 bucket of lime in 7000 gallons....	In 212° F.	85.2	
Same	Out 161° F.	83.1	2.1
Juice in settlers for 26 hours.			
Over-limed + formalin 1 part in 7000	In 212° F.	82.0	
Same	Out 160° F.	80.5	1.5
Limed neutral to litmus + extra bucket of lime	In 212° F.	84.6	
Same	Out 169° F.	82.5	2.1
Limed neutral to litmus + 10 lbs. soda ash per 7000 gallons........	In 212° F.	83.4	
Same	Out 165° F.	81.3	2.1
Juice in settlers for 25 hours.			
Over-limed	In 185° F.	82.3	
Same	Out 160° F.	80.4	1.9

Mr. Walker reports the following under "Hot Juices":

Frequent stoppage for lack of cane in 1921 gave us an opportunity to check up on deterioration in the settling tanks. Following is an average of 207 analyses representing 207 tanks held on the average 11.903 hours per tank:

IN			OUT		
Brix	Pol.	Purity	Brix	Pol.	Purity
14.42	12.02	83.32	14.44	11.98	83.01

Loss in Purity 0.313.

We still follow the system outlined several years ago of heating only to 180° F. that juice which is to be held in the settling tanks for more than an hour or so. When running steadily we average about 200° F. in the settling tanks, as a much lower temperature seems to retard settling.

Carpenter and Bomonti (*Hawaiian Planters' Record*, 1921, XXV, page 171) say that "The experiments of H. S. Walker and A. Fries cited in the 1920 report of the committee on juice deterioration indicate that bacteria are active in hot juices." As a matter of fact none of my experiments indicated such a condition. On the contrary they showed that at temperatures above 170° F. the rate of decomposition of cane juice increased rapidly with the temperature and that such deterioration was brought about by heat, not by bacterial action. The experiments of Carpenter and Bomonti although covering a different temperature range (122° to 176° F.) and demonstrating the effect of heat resisting bacteria, also showed a marked deterioration, even in sterile juice, increasing with the temperature. The large loss in purity they obtained with sterilized and unsterilized juices at 176° F. does not accord with ordinary factory practice and would suggest something abnormal in the juice they used.

The old researches of Herzfeld on the decomposition of very slightly alkaline sucrose solutions although not necessarily applicable to factory conditions, are worth remembering in this connection. The amount of sucrose decomposed per cent on that originally present or, very roughly, the drop in purity, per hour in a ten per cent sugar solution was at

176° F.	.0444
194° F.	.0790
212° F.	.1140

The loss at the boiling point was about two and one-half times as great as at 176°. Taking 176° F. as the average temperature of juice held over at Pioneer, we would expect then a loss in sucrose in 12 hours of 0.53% of the total. Our actual average loss in purity on 207 samples was, as reported above, 0.31%.

During the 1921 season we made three laboratory tests on the deterioration of juice by heat resisting organisms. A bucket of hot juice from the settling tanks was poured into a number of 200 cc bottles and allowed to stand at laboratory temperature. The bottles were rinsed out with boiling water and drained just before filling, then plugged with absorbent cotton. The polariscope reading of different bottles of clarified juice from time to time was as follows:

Hours	0	15	24	38	64	115
Reading	34.0	34.0	33.1	33.0	32.9	32.4
Loss % total	0	0	2.6	2.9	3.2	4.7

The deterioration was slow and irregular. It had been expected that once started, decomposition would go on with increasing speed as in the case of raw juice. The experiment was stopped on account of running out of samples, though the last one polarized was not visibly "sour."

A similar test, made on the limed and heated juice entering the settling tanks, ran as follows.

Hours	0	24	48	72	96
Reading	45.0	44.7	44.3	41.9	"Sour"
Loss % total	0	0.67	1.6	6.9	

This juice spoiled much quicker than the clarified juice. The sample kept 96 hours had changed in color to a light yellow and was too sour to clarify with lead subacetate. Apparently the mud, which had not been removed as in the first experiment, had a bad effect on the keeping qualities of the juice. To test this another experiment was run on clarified juice:

Hours	0	25	33	48	57
Reading	45.9	45.75	45.60	45.45	44.0
Loss % total	0	0.33	0.65	0.98	4.1

Deterioration was slower at the start, but after 57 hours was worse than in either of the other tests. The last sample was sour and the reading doubtful as it was hard to get a clear filtrate.

These experiments may indicate the action of heat resisting bacteria such as found by Carpenter and Bomonti or of other organisms whose spores withstood a temperature of 200° F. Accidental infection after hot juice had been taken from the settling tanks may also have been possible. In the second experiment the temperature of the juice at the time of filling the bottles had dropped to 138° F. It might be worth while repeating these experiments under better bacteriological control than obtains in a sugar factory laboratory.

Deterioration of juice held over in settling tanks may be caused by bacterial action, by the effect of heat, or by both these agencies together. From 212° F. down to about 160° F., decomposition is brought about by heat, and is much less at the lower temperatures. Below 160° thermophilic bacteria may function, producing an acid which inverts sucrose. Losses may be minimized by liming juice which is to be stored to a decided phenolphthalein alkalinity, heating only to a temperature high enough to prevent cooling below 160° during storage and storing in well insulated and covered tanks. It is possible that re-infection of partially cooled juice in uncovered tanks may do more damage than the bacteria originally present.

To be independent of the few Saturday night shut-downs at Ewa, we planned some thermos bottle experiments to test the different preservatives and the effect of heat at the same time. Quart thermos bottles were used. The time of incubation in Experiment I was 28½ hours.

EXPERIMENT I.

	Treatment	Purity
	Mixed juice check	79.2
A.	Slightly alkaline to litmus, in 212° F., out 144° F.	77.2
B.	As "A" + formalin 1 part in 3800, in 212° F., out 144° F.	77.2
C.	As "A" + 1 gm. Na_2CO_3 in 1 qt. of juice, in 212° F., out 152° F	77.2
D.	As "A", in 185° F., out 140° F.	77.2
E.	As "B", in 185° F., out 140° F.	77.2
F.	As "C", in 185° F., out 138° F.	77.2

There was no appreciable effect due to variations in temperature or preservatives.

Two portions of mixed juice, "A" and "B", were limed to barely blue on red litmus paper, in the second experiment.

EXPERIMENT II.

Temperature	Purity	Drop after 2½ Hrs.
A. In 180° F.	80.1	
Out 171° F.	79.8	0.3
B. In 212° F.	80.65	
Out 190° F.	80.1	0.55

If heat is responsible for the difference in purity drop, the increase with higher temperature is somewhat in the proportion given by Herzfeld. (See Walker's letter.)

Experiment III was mixed juice limed slightly alkaline to litmus when cold, (no preservative).

EXPERIMENT III.

Temperature	Purity	Drop after 4¾ Hrs.
A. In 180° F.	77.8	
Out 163° F.	77.15	0.65
B. In 212° F.	77.65	
Out 192° F.	78.2	+0.55

To test the effect of heavy liming and heat, mixed juice was limed distinctly alkaline to phenolphthalein when cold, in Experiment IV.

EXPERIMENT IV.

Temperature	Purity	Drop after 3½ Hrs.
A. In 180° F.	77.3	
Out 172° F.	77.15	0.15
B. In 212° F.	77.70	
Out 190° F.	78.10	+0.40

In Experiments III and IV, an increase in purity with the higher temperature and heavier liming may be due to the destruction of glucose.

Experiment V was mixed juice slightly over-limed to litmus.

EXPERIMENT V.

Temperature	Purity	Drop after 3½ Hrs.
A. In 180° F.	78.9	
Out 167° F.	78.5	0.4
B. In 212° F.	79.1	
Out 191° F.	79.1	0.0

A few tank experiments were carried out with mixed juice heavily limed without the use of preservative, and the following results were obtained:

Temperature	Purity	Drop after 28 Hrs.
A. In 185° F.	83.3	
Out 148° F.	80.6	2.7
B. In 184° F.	82.3	
Out 159° F.	79.7	2.6
C. In 185° F.	82.3	
Out 162° F.	81.1	1.2

Mixed juice, limed neutral to litmus plus formalin one part in 5000, was put in at 180° F. and taken out at 148° F. The purity of the juice at the beginning was 81.5 and after twenty-eight hours, it was 74.6, showing a drop of 6.9.

At Ewa we heat the juice to be kept in tanks to 212° F. in order to be sure that the temperature does not sink below 160° F. As preservatives, we over-lime and add formalin, one part in 3000. It appears to us that in our case it is more important to prevent the juice from cooling below 160° F. than to try avoiding the effect of the higher heat on sucrose.

PRESS CAKE

It seems reasonable to expect that, if deterioration has started in the mud-presses, the polarization of the discharged mud should continue to go back during the first hour or so. A number of tests made at Ewa showed no drop in polarization during the first two hours. The polarizations of the cake used in the experiments ranged from 4.3 to 1.0. Apparently then no appreciable deterioration in mud-presses needs to be feared if no large storage tanks are used, if the settlings are kept hot and alkaline, and only the hottest water available is used for sweetening off. These are the precautions that were taken during the experiments. If sweetening off is unduly prolonged it may be advisable to keep the water also alkaline. We did notice that when water was kept in longer than three hours it had a tendency to run acid. Extremely low polarization of the mud is in such cases most probably due to inversion.

SYRUP AND MASSECUITES

It is generally accepted that deterioration in the sense of destruction of sucrose does not take place in these products under ordinary circumstances, if they are not allowed to become distinctly acid. If the difference between gravity purity and apparent purity in mixed juice and the syrup coming from it is an indicator, a slight destruction of glucose is shown in our case, where the difference is for mixed juice 1.02 and for syrup 0.89.

Tests made at Ewa show that no deterioration went on in the crystallizers. Glucose: Polarization ratios, established for seven crystallizers from day to day at different times of the season, remained without change for as long as fourteen days. A few short runs on massecuites stored in tanks, however, gave us reason to suspect deterioration there.

Mr. G. F. Murray of Hamakua Mill sent us these notes:

Replying to your favor of recent date asking for data on Juice Deterioration, would say that I have nothing original to contribute.

In ordinary week-day practice, I find that by heating the juice to 210°-212° F., and liming to distinct alkalinity to litmus, I get the best results. Any material deviation from this invariably results in poor clarification, and underliming, that is, liming to neutrality or slight acidity to litmus, results in a decidedly acid juice and this in turn to a decided loss in sucrose.

A clasification test, conducted by Mr. McAllep, while on a visit to this mill, might be of interest. The test started at 10:30 a. m. on June 15, 1922, and lasted one hour and thirty minutes. The stations concerned were run on the usual schedule. Mixed juice, clarified juice, resettled juice, mud press juice, and syrup samples were composited in proper sequence in order to get, as nearly as possible, the same juice throughout. The results of this test were as follows:

Juice	Temperature	Purity
Mixed		86.00
Clarified	206°-208° F.	87.26
Resettled	180°-190° F.	85.7
Mud Press	210°-212° F.	84.4
Syrup		86.6

The apparent drop in purity of resettled juice and mud press juice is accounted for by the addition of lime at the resettling tanks. This lime raises the brix of the juice, thus lowering the purity. There was no evidence of destruction of sucrose as the juices in question were distinctly alkaline and up to proper temperature.

After the mill shuts down Saturday evening the juice left over in the clarifiers is further limed at the rate of 5 gallons of milk of lime per 1000 gallons of juice. No other preservative is used, as I find there is no loss in purity if the juice is not kept longer than 24 hours.

I add a half gallon of formalin to each tank of syrup in order to sterilize the foam and sides of the tank.

This is all we have to offer from Association members. The report may close with the only article pertaining to the subject which I was able to find among the last two years' publications. In the Java *Archief* of 1921 G. Loos and A. Schweizer write:

Last year the authors drew attention to the rapid diminution of the polarization of bagasse on keeping. On further examining this phenomenon, it was ascertained that if the sample is so chopped that the outer layers of the cane are very finely divided, the polarization falls from 3—0% in about seven hours, whereas if the rind remains more or less intact, and therefore mostly only the pith passes through the sieve, the deterioration is much less rapid. Presumably this action is due to an enzyme or other agent present in the rind of cane.

It is not very difficult to believe that when the last mill juices are used for maceration they should deteriorate at least as quickly as the bagasse juice, seeing that they are distributed over such a large surface of crushed cane. A study of the control figures of Modjokerto factory, Java, relating the purity of the first and last mill juices appears to prove this. Thus the differences in the purity of the first and last mill juices in the case of a plant having a crusher and four mills, and macerating with water alone was 5.0 with one factory and 7.7 with another; but was 11.1; 13.0 and 14.8 in the case of three others using the last mill for their maceration; and 8.1 when water was used during the first half and last mill juice during the second half of the campaign.

The Importance of Seedling Propagation As Illustrated By H109*.

By W. P. ALEXANDER.

If one were to analyze the problem of cane improvement as it affects a specific plantation, he would have to answer the following questions:

Am I growing the varieties of cane that are best suited to my local conditions in general?

Have I determined the specific variety adapted to each section or different fields on the plantation, i. e., have I a different cane for my lowland, my uplands, poorly drained fields and ideally located fields?

Could I replace, if necessary, any of my varieties with a good substitute, i. e., am I prepared for the eventual failing of my standard varieties?

Provided one is able to answer these three questions in the affirmative, then I believe he is ready to ask:

Have I the superior strains of my varieties?

Is it not possible to isolate a better strain?

Can I eliminate the poorer strains of the varieties?

Will not continual selection of my planting material insure the permanency of my variety and prevent its decline?

The propagation and selection of seedling canes is a proved proposition in the Hawaiian Islands, as elsewhere in the world. The results obtained have been above expectations. A variety of cane has been produced which is resistent to the root-rot known as the Lahaina disease. It is now grown on over 50,000 acres. This has all been accomplished in a period of ten years.

I will sketch the history of the development of this cane briefly, a variety whose worth in money to the sugar planters has been placed at millions of dollars.

In December, 1905, the first large sowing of seed from the tassels was made by the Experiment Station of the Hawaiian Sugar Planters' Association, of which C. F. Eckart was the director of the Division of Agriculture. H109 was one seedling out of the 5232 which were propagated in 1905-1906. It came from a Lahaina tassel. Whether it was self-fertilized or fertilized by stray pollen of another variety is not known.

The nursery work connected with propagation of cane seedlings is not very difficult. It requires a knack and intuitive skill to be able to get the seedlings in the ground. This I have found to be the case from personal experience.

The real task presents itself in the proper selection of the new canes. It is a matter of elimination of the undesirable. How this was done in the first

* Read at the first annual meeting of the Association of Sugar Technologists of Hawaii; Honolulu, November 15-18, 1922.

H. S. P. A. propagation is shown below*:

Year.	Canes Grown.	Number Eliminated.	% Discarded on 1st Planting.
1906	5232	....	.....
1907	1159	4073	77.84
1908	802	357	6.83
1909	349	453	8.66

No big attempt during this period was made to raise more seedlings, as all effort was concentrated in discarding the poorest and retaining the best. After three years 6.67 per cent were retained and among them was H109.

The pioneers in this seedling propagation were well repaid for their painstaking work in getting these new varieties ready for the actual growing conditions of the plantations. They followed the policy laid down in 1906,† namely:

To distribute no cuttings of Hawaiian seedlings until about three and one-half years had elapsed since seed was sown, for the reason that it would not be possible during a period of less than that time.

To select seedlings according to field characters.

To test and select seedlings with respect to juice analysis, etc.

To estimate cropping value of the plants by plot tests.

To grow sufficient seed cane from seedlings for distribution among plantations.

In 1908, thirty-one seedlings, including H109, were considered worthy of studying under plot conditions. In the test, harvested early in 1911 at Makiki, H109 ranked eighth for twenty-month-old canes, and in 1912 a short ratoon test, H109 ranked fifth.

The results from the first shipments of H109, sent to the plantations in 1909, began to be heard from in 1912. In most cases the few lines of cane planted from the original seed material from the Station was cut for seed as soon as possible and planted out again. At that, the areas were very small. Very encouraging reports concerning H109 came from Aiea, Waimanalo, Kilauea, McBryde, and Ewa.

At the first named place, Honolulu Plantation, the yield in a single line test was 114 tons of cane per acre as against 86 tons per acre for the Lahaina check line.

Except for Ewa, none of these five plantations, where preliminary tests were so favorable, continued at that time to spread H109. It remained for George F. Renton Sr., Manager of Ewa Plantation Company "to put H109 on the map". His strong convictions are reflected as early as 1909 in the report of the Committee on Cultivation, Irrigation, and Fertilization of that year. He said:

The raising of Hawaiian seedlings and other varieties of previously imported canes on every plantation, so as to enable us by thorough test to compare them with our standard Lahaina, is something the importance of which cannot be overestimated. It is now being done by all of us. What it is wished to emphasize in this brief allusion to this subject is the importance of growing a sufficient quantity of, and of testing, the most prom-

*Exp. Sta. Report, 1917.

†Exp. Sta. Report, 1906.

ising of these varieties on fairly large areas, in various locations on each plantation. The reason for this is that not always can sufficiently definite results be obtained on a small experimental plot, which merely indicates the preeminence of certain varieties on that particular location or plot. As a matter of fact, a number of plantations contain several different soils within their boundaries, and, unless experiment stations are conducted on each of these different soils, results are apt to be misleading. * * * * * Hitherto all the irrigated places have pinned their faith principally to Lahaina. It is a splendid cane, with magnificient ratooning qualities. Perhaps, however, the time may come when diseases or insect enemies may sap its strength. And if this should happen, it would be well for us to be prepared to substitute another variety or other varieties which have been found by test to be suitable, and from these fairly good-sized areas before referred to, obtain sufficient seed canes with which to effect the change in the shortest space of time. It is an old saying that "sugar is made in the field". Certain it is that the condition of our fields is of prime importance.

It was by applying definitely in practice these ideas that he was able to select H109 from many other canes and demonstrate that for his conditions H109 was the cane he was looking for.

H109, by 1913, was being tried out on five sections of Ewa Plantation, each with a different soil condition to contend with. Along with H109 was being tested practically every variety and seedling in existence in the Islands. The areas planted to each variety were not very small. The yields from H109 led them all.

Enough seed was accumulated in 1911 to plant over one-half an acre. It was planted with other varieties in Field 13-C, where conditions were not of the best. To shine here, a cane had to be A No. 1. The yield obtained was excellent, 81.19 tons of cane per acre as against 67.92 for an average of Lahaina and other varieties. This was in spite of the fact that seed was obtained from this plot to plant a larger area.

In 1912 Field 20-C, an area of 25.2 acres, was planted solid to H109. Lahaina had failed badly here, but H109 grew well. It yielded as high as 78.38 tons of cane per acre, and 10.45 tons of sugar, with a quality ratio of 7.5. This crop gave 90 tons of cane per acre from the fourth ratoons.

There was now no longer any question in the mind of Mr. Renton that H 109 was the cane to meet Ewa's conditions. All his patient, persistent work in experimenting had been rewarded. He planted 281 acres to H109 that year. It required courage to extend this new variety so rapidly, for others had not yet been convinced that here was the cane to solve the Lahaina disease problem, a truly resistant variety that was as good, if not better, than Lahaina.

Ewa Plantation had planted 2500 acres by the end of 1916 before its example was really followed on a large scale by the other plantations. Since then almost all plantings on all irrigated lowlands in the Islands have been confined to H109. This is a sure tribute to George F. Renton Sr. Within three years from the time he received the first H. S. P. A. Experiment Station seedlings he led the way in selecting and planting on a plantation scale the one cane that now leads the world in tons of sugar produced per acre on 288 acres.

The success of this seedling cane, H109, is so real and personal to everyone situated on an irrigated plantation, that it should fire the imagination of all those in the industry. It should make us feel "that no stone should be left unturned"

until a variety has been found that will be adapted to each and every condition of cane culture which we have to deal with in the Islands. We hear rumors that Yellow Caledonia, grown on 100,000 acres, about half the total area on plantations, has seen its best day, and is on its decline. Are we prepared to put in the place of Yellow Caledonia a cane that is equal to it or better? If so, I have not heard of it. The Tip canes are ideal for many locations and yet cannot grow there profitably on açcount of Yellow Stripe disease. Is there a cane that will equal undiseased Tip canes on mauka fields?

Take our thoroughbred cane, H109, that responds so to ideal conditions, it has its weaknesses, being very susceptible to leafhopper attacks and the leaf disease, Eye Spot, and also to a terrible foreign disease in Fiji. Are we in a position to substitute for H109 that cane which would be resistant to this dreaded stranger, the Fiji disease, should it accidentally come here?

We are not yet in a position where the propagation of seedling canes and their selection in the field can stop. We never shall be. On the other hand, the opportunity for new varieties was never greater, for we know we are working on a sure thing. The supremacy of H109 has taught us that. What has been done in securing a first class cane for the most productive fields on the Islands can be done for the less productive lands. There is an urgent need to have an "understudy" for every one of our standard canes. It is more than insurance against possible calamity. It is a necessity.

In this plea for more and better seedling work, there is no intention of belittling or depreciating the present enthusiasm and desire to secure by means of bud selection the improvement of cane varieties. I believe the two projects go hand in hand. There should be no conflict between them. Each deserves our immediate attention.

In this paper, I stress the seedling work only because I understand others more competent than I are to handle the other phase of cane improvement. However, I would like to say that in the history of plant breeding, the greatest resistance to disease has come about in varieties that have been produced by seedling work, in contrast to strains originating as bud sports.

The securing of new varieties by sowing the cane tassel, watching the tiny plants grow, transplanting them, and caring for them until they have developed cane stalks from which the first seed cane can be secured, is fascinating work. The most unskilled can do it. The Ewa school children raised several hundred seedlings last year. The more important future trials with frequent eliminations of the worthless canes requires patient testing and careful observations over a long period of time. There is that gambling element in this work which has its appeal. H109 was one chance out of 5000, but for the careful selection work of Mr. Eckart and his associates it might have been lost for all time. The Experiment Station and its staff needs the cooperation of every individual on the plantations who will raise a few seedlings.

In 1920 and 1921, at Ewa, there were five individuals who were propagating seedlings. At Olaa, Hilo Sugar Company, and Honomu there are plantation overseers and chemists who are raising seedlings to beat the old timer, Yellow Caledonia. The evolution of H109 at Ewa only encourages us to work harder for new varieties. We know at first hand what a seedling can do.

Since 1914, I venture to state that at Ewa more experimental area has been in seedling canes than on any other plantation, though Wailuku Sugar Company is running us a close second.

There are now 1094 seedlings under investigation covering a total of 90 acres. Ewa has almost 600 of her own propagation now being grown. This is in addition to 20 acres of the 1920, 1921 and 1922 bud selection experiments. I mention this merely to show how necessary we believe seedling work to be, in spite of the fact that H109 stands head and shoulders above all.

The profitable production of sugar in Hawaii will always be based on the growing of a suitable cane variety. Our conditions are so different on the same plantations and from one plantation to another that varieties adapted to every environment are necessary. We haven't them now. The chances of variety deterioration due to disease or inherent qualities are always present. Quarantine laws restrict the importation of any foreign varieties to meet our needs. Our salvation is the raising of new varieties through propagation of our own seedlings. If our interest in this endeavor lessens, let us remember that H109 had its beginning as a seedling and that there is every reason to believe that many more similar successes can be achieved in a like manner.

The Availability of Plant Food As Measured By Plant Analysis.

A REVIEW OF THE LITERATURE

By W. T. McGeorge

In 1840, although based on earlier work of de Sausure, von Liebig advanced his mineral theory of plant nutrition. Following this we note numerous attempts to measure the plant food needs of the soil or plant. Such attempts have apparently reached their climax in the last few years as evidenced by the recent attitude taken by the Association of Official Agricultural Chemists, an organization of the leading chemists engaged in this field in United States. In their methods of analysis which are the "Hoyle" of agricultural chemistry, we note that the old official method of soil analysis has been discarded. In its stead has been suggested, but not adopted as official, the absolute determination of the mineral constituents. This would indicate that the "brains of the industry" had either given up in despair or had decided to start over again with a clean slate.

Attempts to correlate fertilization practices with soil composition have been along three rather definite channels: First, the analysis of the soil; second, the simulation of the feeding power of the plant by extracting the soil with weak acid solvents; and third, the analysis of the plant through the ash. In the smaller grain crops the latter method has been applied quite extensively. With numerous

other crops this method is possible but hardly practical and we might almost say with impunity that with sugar cane we reach the other extreme where circumstances make such a proceedure practically impossible.

A very novel method and one that presages considerable value has been suggested by Herbert Walker in the last *Record,* namely, the analysis of the crusher juice. It is possible by this means to obtain samples representing almost any desired section of the plantation. A somewhat similar proceedure was used by P. S. Burgess in his comparison of the potash content of molasses with the analysis of the soil, which, however, is limited to the plantation as a whole and lacks the advantages of the analysis of the crusher juice.

In view of the surprising lack of response to phosphate and potash on many of the Island sugar lands, it is obvious that any method which promises aid in the formulation of fertilizer practices is well worth a thorough study. It is interesting to note in this connection previous work on "the analysis of the soil through the medium of the plant."

This field of endeavor is quite thoroughly covered by Johnson in "How Crops Grow".[1] The information therein represents a general survey of the literature. Among the important points which he brings out are: different parts of the same plant yield unlike proportions of mineral matter; the upper and outer part of the plant contains the most mineral matter; the same plant in different stages of growth varies in proportion of mineral matter to dry matter; the influence of soil and season causes the proportion of mineral matter in the same plant to vary; different varieties of the same plant grown on the same soil will vary; ash content of healthy and vigorous plants varies from that of weak and stunted.

E. von Wolff has compiled thousands of ash analyses in his book "Aschen-Analysen von Landwirth-schaltlichen Producten Fabrik-Abfallen und Wildwachsenden Planzen" which is a constant source of reference for agricultural chemists. Briefly stated, his data show a wide variation in the ash composition of the same plants grown under different environments.

Turning to more specific data we note the most extensive investigation of this problem is that of Hall[2] of the Rothamstead Experiment Station who reports in considerable detail his work on oats, wheat, barley, potatoes, swedes and mangels. This work so closely correlates local proceedure, even to a comparison of the citrate soluble phosphate in the soil, that it may not be amiss to present some of his data.

Cereal Crops.

Oats were grown in pots on six different soil types, the plants analysed at maturity and the phosphate content of the ash compared with that in the soil soluble in 1% citric acid.

Soil No.	Per Cent. P_2O_5 in Plant Ash (Average)	Per Cent. P_2O_5 in Soil Sol. In 1% Citric
1..........	10.89	.142
2..........	7.46	.0401
3..........	6.10	.0144
4..........	5.41	.0115
5..........	4.80	.0210
6..........	3.91	.0023

Field experiments on these soils showed that only No. 6 was in need of phosphate fertilization. Hall found considerable variation in the phosphate content of the ash and from the results as a whole concludes that the analysis of the soil with 1% citric acid indicates the characteristics of the soil towards phosphate manuring much better than the analysis of the ash. For example he cites soils Nos. 5 and 6, the former of which does not respond to phosphate manuring, yet his analyses of individual plants showed some grown on soil No. 6 to have absorbed more phosphate than those grown on soil No. 5. It is clearly evident, however, in spite of his conclusions, that the averages are in remarkable accord.

He has further studied the influences of fertilization on the phosphate content of the ash and shows that a greater increase in citrate soluble phosphate is to be found in those soils fertilized for extensive periods than is shown in the analysis of the plants grown thereon. Extensive analyses of plants grown from season to season at Rothamstead indicate that an unmanured plot, impoverished in all directions, may yield produce with much the same ash composition as one that is rich, being equally supplied in all directions.

Root Crops

Hall's analyses of swedes are given in the following table and compared with the citrate soluble phosphate in the soil:

Soil No.	Per Cent. P_2O_5 in Ash	Per Cent. Cit. Sol. P_2O_5 in Soil
1..........	8.96	.0199
2..........	9.10	.0129
3..........	10.56	.0203
4..........	10.91	.0123
5..........	11.18	.0135
6..........	11.81	.0088
7..........	12.77	.0073
8..........	15.01	.023
9..........	15.85	.0324

Soils Nos. 1 to 6 have given response to phosphate manuring in field experiments, while Nos 8 and 9 have not. In commenting on these results he says that they are in very satisfactory accord.

Hall's general conclusions are that the proportion of phosphate in the ash of any given plant varies with the amount available in the soil. The extent of this variation is, however, limited and often no greater than that due to variation in season or other variations induced by difference in supply of ash constituents. These fluctuations are reduced to a minimum in the case of organs of plants which, like the grain of cereal crops and the tuber of potatoes, are manufactured by the plant from material previously assimilated. Root crops like swedes and mangels are more affected by changes, the phosphate requirement of the soil being well indicated by the composition of the ash of swedes grown unmanured although the extraction of the soil with 1% citric acid gives more decisive information.

While Hall's conclusions appear more or less adverse to the value of plant analysis as compared to the extraction of the soil with 1% citric acid it is evident that he interpreted his data with the idea in mind of finding a plant which could be generally adapted to measuring phosphate deficiencies.

Another extensive investigation in this field is that of B. Tollens[3]. He mentions among the factors which influence the variation in the composition of the ash, stage of growth, the soil, fertilizers, available moisture, and thickness of stand. He has tabulated the variation in the phosphate content of the ash of some typical plants as follows:

Plant—	Per Cent. Ash	Per Cent. P_2O_5 in Ash
Meadow Hay	2.2-11.4	2.0-21.3
English Rye Grass	7.5-15.	6.2-16.0
Red Clover	4.5-9.2	4.0-15.0
Winter Wheat	1.6-2.5	39.2-53.7
Maize	1.0-1.7	37.6-53.7
Winter Wheat Straw...	4.5-7.0	2.2-8.9
Potato Tubers	2.2-5.8	8.4-27.1
Potato Leaves	5.2-12.9	2.6-12.1

He cites numerous experiments and analyses showing the composition of plant ash at various periods of growth and the needs of larger quantities of plant food at certain definite periods. Other experiments cited show variation in the composition of the ash of plants grown on different soils. The influence of fertilization on ash composition is also shown by experiments and analyses. Too much or too little water may influence the composition as shown by data cited, and the thickness of the stand is shown to be a factor in other analyses and experiments.

Tollens, while he points out the need of more extensive study, says that the fertility of a soil might be measured by growing crops adapted to the particular soil and analysing the plant.

Heinrich[4] has used the oat plant in measuring plant food defiiciencies and analysed only the roots. Where P_2O_5 content of the dry root fell below .08-.10% he concluded the soil was deficient. Dikow[5], in similar work on barley, fixed the minimum at .13% P_2O_5 in the dry roots. Helenkampf[6] carried on similar work and concluded that when there was an increase in P_2O_5 content of the dry matter of the crop as a result of fertilization the need was indicated. M. Stahl-

Shroder[7] tested Heinrich's system of root analyses and also another method, using the seed analyses and found the former to be of no value and, while the latter was not of general application, he suggested that it might be applied to particular climatic and soil conditions. Savvin[8] working on small grain crops found that the total P_2O_5 in the straw and in the entire plant can indicate the need of fertilization. If the phosphate supply is abundant it enters the plant in greater quantity. Herbert and Truffaut[9] claim from their experiments that a rational basis for fertilization may be furnished by the analysis of typical plants grown under normal conditions. They claim that in a given species of plant grown on a given soil, the use of fertilizer increases the yield but does not affect the mineral composition.

It is notable in reviewing the literature that little attention has been given to this method of studying soil deficiencies in United States. The only serious attempt is that of Hartwell[10] at the Rhode Island Experiment Station. At the outset of his experiments, using oats, millet and turnips, only in the latter crop did the per cent. phosphate appear to be markedly influenced by the available supply in the soil. He found a decided relation between the inorganic phosphate in the juice of the turnip and the available phosphate in the soil. His experiments were quite extensive and included analyses of crops from plot experiments in different sections of the state, grown under different soil conditions, environment, fertilization and moisture supply. The idea was to determine whether or not the turnip could be applied generally over the state as a measure of available phosphate in the soils of the state.

The following points which he cites may be of interest. The percentage of an ingredient in field crops may depend on one or more variable factors which may or may not affect absorption in the same degree. Even if the extent of the influences could be determined there would still be the difficulty of knowing which of the factors influenced the growth. His work, however, showed that "the percentage of phosphate is quite variable in the turnip, depending at least considerably on the amount of phosphate available in the soil". It is interesting to note that 70% of the phosphate in the turnip is inorganic and practically all soluble in the juice and that an increase in the supply of available phosphate in the soil increases the phosphate content of the juice in proportionately larger amounts than the total phosphate content of the turnip.

It was found that in similar seasons the percentage of phosphate in the turnip from soils in different sections of the state usually varied in the same direction as the amount of available phosphate in the soil, and it seems probable, especially under similar climatic conditions, that the relative amount of available phosphate in different soils may be indicated by the relation between the per cent. phosphate in the turnips grown on those soils. To illustrate the variation in the per cent. phosphoric acid in the dry matter of the turnip, .27% was found in the turnips grown on an extremely deficient soil while 1.82% was found in those grown on a soil abundantly supplied. He calls attention to the variation in the per cent. phosphate with the age of the plant, being much higher in the young plants as compared with the mature.

The writer[11] analysed buckwheat and millet plants grown in phosphate experiments on Hawaiian soils deficient in phosphate with and without phosphate

manuring and found little or no variation in the phosphate content of the plants. Attempts were made to grow turnips and radishes in these same experiments but were abandoned due to inability to protect the large number of pots from insect ravages.

Summary.

A review of previous studies on the relation of available plant food to the mineral composition of the plant shows that this field of endeavor has not been given the attention in the United States which it has received in Europe. While more or less conflicting results have been obtained by different investigators, the more complete studies, we might conclude, indicate that the analysis of the crusher juice should lend valuable information regarding the available plant food constituents in our soils. It should be remembered, however, that the composition of the plant mineral matter varies at different periods of growth, that the amount of several mineral nutrients which a soil must furnish to a crop in the earlier stages of growth is greater than the crop contents at maturity, and that in the specific case of phosphate in our own soils, where the fixing power is so high that little or none added as fertilizer goes below the first foot, indicates that where a response is obtained on Hawaiian soils, it is due principally to its stimulating influence on the young cane.

References.

[1]How Crops Grow.
[2]Jour. Agric. Science, Vol. I, p. 65.
[3]Exp. Sta. Record, Vol. VIII, p. 305.
[4]Exp. Sta. Record, Vol. XIII, p. 316.
[5]Exp. Sta. Record, Vol. XIII, p. 316.
[6]Exp. Sta. Record, Vol. XIII, p. 316.
[7]Exp. Sta. Record, Vol. XVI, p. 28.
[8]Exp. Sta. Record, Vol. XXXVI, p. 622.
[9]Exp. Sta. Record, Vol. XV, p. 763.
[10]R. I. Exp. Sta. Bull. 154.
[11]Haw. Exp. Sta. Bull. 41.

Sugar Cane Improvement.

H8949, a seedling of H109, makes a good showing in comparison with the parent cane.

A field of selected Yellow Caledonia at Hakalau Plantation, planted June 6, 1922, and photographed in October. Photograph submitted by J. M. Robertson.

Wailuku No. 15, a promising seedling propagated in 1917, of Lahaina parentage.

Recent Bud Selection Work.*

By A. D. Shamel.

Bud variations are of frequent occurrence in plants propagated by budding or other vegetative methods. As some one has said, "Variation is the only invariable thing in nature." The variations observed in vegetatively propagated plants may be classified, for the purpose of this discussion, as (1) those which are inherited, and (2) those which are not inherited. The inherited bud variations are the ones of importance in this discussion as the others are largely the result of changing environmental influences and are not, so far as we now know, of any direct importance in the work for the improvement of plants through bud selection.

The fundamental objects of our bud selection work include (1) securing new and better varieties through the selection of striking and valuable inherent bud variations; (2) the isolation and propagation of strains of established and commercially valuable varieties which possess characteristics of greater merit or value than those of the parent varieties; and (3) the bringing up of the average performance of the population of valuable strains to that exhibited by the maximum individual performance, or, as nearly so as is found to be practicable.

The Washington navel orange is a striking example in the citrus of the possibility of securing valuable varieties through the discovery and propagation of valuable bud mutations. About one half of the sugar production of the world derived from sugar cane is produced by varieties which originated as bud mutations. Within recent years a great industry has developed in the United States in the propagation of varieties of the Boston fern which have originated as bud variations. An ever-increasing mass of evidence is accumulating which shows beyond any question of doubt the importance of bud variations as sources of improved varieties of plants. I have brought together some of this evidence which has been published by the Experiment Station of the Hawaiian Sugar Planters' Association in a bulletin entitled, "The Improvement of Plants Through Bud Selection."

In our citrus varieties, as in other vegetatively propagated varieties of plants, numerous strains have originated as bud variations during the past fifty years and have been intentionally, or as has been more often the case, unintentionally propagated by nurserymen and growers. Some of these strains are valuable for the economic production of food products, while others are undesirable and worthless for commercial propagation.

In these citrus varieties we have isolated through bud selection several distinct strains of each of the varieties studied. On account of the lack of time it is impossible to discuss this work in detail here, but those who are interested will find it described in a series of U. S. Department of Agriculture bulletins:

*Paper read at the meeting of the Lemon Men's Club, California, August 2, 1922.

No. 623, A Study of Bud Variation in the Washington Navel Orange; No. 624, A Study of Bud Variation in the Valencia Orange; No. 697, A Study of Bud Variation in the Marsh Grapefruit and No. 813, A Study of Bud Variation in the Eureka Lemon; and No. 815, A Study of Bud Variation in the Lisbon Lemon.

In potatoes, sugar cane and many other crops, similar work for the isolation of strains has been or is now being carried on. When the strains have been isolated, their value compared and studied, the superior ones are multiplied through the propagation of the best individuals, and the inferior ones are eliminated so far as commercial propagation is concerned.

In the valuable strains inherent variations in the habits of production of the individual trees or other plants have been discovered. Through the selection of inherently superior parent plants for propagation it has been discovered that it is possible to bring up the average production of these strains to, approximately, that of the best individuals, in other words, to lay the foundation for the production of uniformly good crops.

The great economic possibilities of bud selection work, in my opinion, lie in the third phase of this work. The Utah Agricultural Experiment Station present in their bulletin, No. 176, entitled, "Potato Improvement by Hill Selection," definite scientific evidence on this point. The work described in this bulletin began with experimental propagations of good and poor potato hills in three commercial varieties. The progencies of the poor hills soon became so poor that their propagation had to be abandoned. As a result of the first experimental work, it was decided to concentrate on hill selections in the best variety.

The accompanying table shows a summary of the results of hill selection work with the Majestic variety as compared with unselected plant propagation material from the period from 1915 to 1920 inclusive.

MAJESTIC POTATO VARIETY

Yield in Bushels per Acre.

Year.	Pedigree Selection	Unselected Stock	Pedigree Gain
1915	316.7	179.3	137.4
1916	330.7	191.2	139.5
1917	382.4	269.3	113.1
1918	311.9	202.4	109.5
1920	146.9	117.3	29.6
1919	353.4	184.8	168.6
	307.0	190.7	116.3

Not only was the yield increased through hill selection by more than 60 per cent., but the commercial quality of the pedigree crops was much higher than that of the unselected. The pedigree potatoes possessed more uniformly good size, shape and other important tuber characteristics than the unselected.

At the Central Experimental Farm of Canada, located at Ottawa, a recent report shows that the root-grafted progeny of a high yielding parent healthy apple tree has produced during nine years an average increase of more than 60 per cent., as compared with the yield of a similar progeny from a low yielding

parent tree. In this instance there are no apparent type differences in foliage or fruit characteristics of the parent trees. Top worked progenies of these parent trees showed similar differences in behaviour to the root grafted progenies. Therefore we are forced to the conclusion that in this case the characteristic number or quantity of apples was transmitted from the parent trees to their progenies.

An interesting progress report may be made upon the behaviour of several lemon progenies on the Limoneira and Sespe ranches. While there are no comparative poor yielding progenies available for study in these instances the early, heavy, and uniformly good production of the trees in their progenies grown from carefully selected buds secured from high yielding parent trees is significant. The members of this club who have seen these trees are aware of the remarkable uniformity of tree and fruit characteristics. These trees are so strikingly superior that they excite the admiration of every one who sees them.

LEMON PROGENIES.

Yield in Field Boxes per Tree.

Limoneira Lisbon Trees. 650 Trees Planted in 1913.		Sespe Eureka Trees. 823 Trees Planted in 1916.	
Year.	Yield.	Year.	Yield.
1917 (for 7 mo.)	0.69		
1918	2.53	1918 (for 7 mo.)	0.24
1919	3.83	1919	0.68
1920	5.45	1920	0.74
1921	7.36	1921	1.90
1922	10.00 Est.	1922	3.00 Est.
(1922—7.57 for 7 months)		(1922—2.26 for 7 months)	

While the Lisbon and Eureka progenies are located on different ranches with different environmental conditions and are not comparative, these yield data have been shown in the accompanying table for comparative years from the time of planting. Only very few bud variations have been found thus far amongst the 650 Lisbon trees and a similarly small number have appeared in the 823 Eureka trees. The heavy yields of particularly uniformly good fruits in these progenies can be safely ascribed in large measure to bud selection.

Other recent examples of similar improvements in yield, both as regards the quantity and the uniformly good commercial quantity, with several vegetatively propagated crops might be cited if time permitted. Enough has been said, I believe, to demonstrate the great importance of this work from the standpoint of profitable fruit growing and farming. A vast amount of work along this line is now under way with many crops and the future will show much greater progress than the past. We have just begun to realize the significance of this work, to understand methods of parent plant selection and progeny tests, and to concentrate upon this subject, so that effective work is now possible. There is no mystery about it, only plain common sense, combined with intelligent and

sustained effort. It requires work but the compensation for the work required is far beyond its cost.

The work deemed necessary in order to maintain and improve our established varieties of citrus fruits and to secure its benefits may be divided into two phases, (1) investigation, and (2) commercial.

The investigational bud selection work in the citrus conducted by the United States Department of Agriculture in California was begun in April, 1909, and has been continued uninterruptedly to date. It has included a systematic study of the important commercial varieties by means of individual tree studies in suitably isolated orchards. Most of this work has been carried on in privately owned orchards and with the hearty co-operation of the owners of these properties. It has been done with a minimum of expense. It has been continuous. It has been conducted from the standpoint of discovering the facts. The results have been presented from time to time through demonstrations, conferences with growers, and by means of publications which reach the citrus growers generally. All of this effort in co-operation with the growers, the organizations representing the growers, and with all others concerned, has for its sole object the improvement of production by the industry as a whole for the benefit of both the producers and the consumers of citrus fruits.

During the early stages of the investigational work the individual tree studies were carried on in established orchards. Many strains of the established varieties were discovered which have arisen from bud variations. Some of these strains were found to be valuable while many proved to be undesirable. Careful selections of parent trees were made in the best strains, and progenies propagated in order to lay the foundation for securing inherently superior strains. Some parent trees of inferior strains were selected for propagation so that a comparison of the progenies from selected trees of the good and poor strains can be secured. High and low yielding parent trees in each of the important strains were selected for experimental propagation. We are now engaged in a study of the progeny behaviour of these parent trees. Enough evidence has been secured thus far to warrant the statement that the superior and inferior strains of our citrus varieties can be isolated through bud selection. Furthermore, the progenies of the highest yielding parent trees have thus far given us the highest and best yields, while the progenies of the low yielding parent trees of these same strains have given us the lowest and most undesirable yields. Surely the members of this club will appreciate the tremendous and fundamental significance of these facts.

The investigational work now under way is mainly concerned with the progeny behaviour of carefully selected parent trees. The object is to locate the best progenies for further propagation. In order to secure comparative data it is also essential to study the progenies of inferior parent trees. Enough of this work is being done to secure adequate comparative data. The main effort, however, is to lay the foundation for further improvements of our valuable varieties by the propagation and study of a large number of progenies of the best trees.

I am of the opinion that the established citrus varieties are the most valuable possession of the citrus industry. Without them our efforts would go for naught. These varieties may run out or deteriorate through the intentional or unintentional propagation of undesirable strains arising from bud variations.

Through systematic bud selection we cannot only maintain our varieties, but also improve their production by eliminating the undesirable strains and propagating only the inherently superior progenies.

The commercial phase of this work is the practical use and application of the results of the investigational phase. It is being carried on by co-operative citrus organizations and by individual effort. In order to illustrate the development of this phase, the work of the California Fruit Growers' Exchange will be cited. In May, 1917, this organization established a bud department of the Fruit Growers' Supply Company. C. S. Milliken was placed in charge of this department and its success has been due to his untiring and unselfish efforts and the work of his associates. Since its organization this department has furnished to propagators and growers more than 2,000,000 buds secured from superior parent trees located in many of the best orchards in this state. The work has been self-supporting, a charge being made for the buds sufficient to cover the cost of securing and distributing them. In this work, Mr. Milliken has had the public-spirited support of the leading citrus growers from whose orchards the buds were secured, the nurserymen and growers using the buds, and of every one concerned with the future as well as the present welfare of the industry. This unparalleled demonstration of co-operative effort has already inspired other industries to similar effort and marks an epoch in the history of the world's work for economic food production. While this work has been quietly carried on, and for this reason may have escaped the publicity often secured by more widely advertised efforts, it nevertheless appeals to me as the most important and genuinely successful effort to develop and improve production by an industry as a whole thus far achieved in the history of mankind. It also demonstrates the possibility of an organized agricultural industry as a whole utilizing the results of scientific investigation.

In conclusion, I want to discuss briefly from my point of view, some of the things remaining to be done in order to develop this work to its logical conclusion.

From the investigational side, it appears to me that we are now ready to carry on a more effective search for improved bud variations as possible sources of improved strains and varieties. Owing to our very limited resources we have been able to do thus far only a small amount of systematic search for such bud variations. With the growing interest in this phase on the part of growers and through better resources it now seems possible to achieve this ambition. It means, as I understand it, the systematic search not only of our own orchards, but of citrus orchards in all parts of the world. We should concentrate not only upon California and Florida orchards, but study those in the Mediterranean region and other citrus districts as well.

The progeny records now under way will require several years before final and conclusive data can be secured. Many more progeny studies than those now available must be made. It is in this phase of our work that our efforts will be most strongly concentrated during the next few years.

Co-operative individual tree performance records are of great value in this work. We desire the co-operation of all citrus growers in securing accurate individual tree records of yields. From these data, as has already been demonstrated, definite and reliable information can be secured not only as to location

of superior or inferior producing trees, but as to the effects of different methods of cultural care and other conditions affecting citrus tree behavior. This individual tree record work is not only of direct benefit to the grower performing it, but to the industry as a whole. Out of it is destined to come definite and accurate information as to orchard practices which will be of practical importance to every one concerned in this industry.

The future work of the commercial phase, as I see it, includes not only (1) continuing the work of securing reliable bud wood from superior parent trees for propagation, but (2) the development of improved sources of bud wood through the selection of superior parent trees in the best progenies, (3) the development of reliable sources of supply of improved root stocks (4) the building up of authoritative information as to varietal adaptations, propagating and planting conditions, and the guiding of propagation work along safe and constructive lines, (5) the utilization of the results of scientific investigation along these and related lines so that the individual grower can secure the benefit of this work. This is an ambitious program, but one which experience has proven to be practicable in the California citrus industry.

In order to achieve success in both the investigational and the commercial phases of this work, the active co-operation of all of the growers must be secured. The members of this club, with whom I have had the pleasure of long and active association, have always led in such co-operative efforts. I feel that we have now reached a point where we can logically ask for your further co-operation in the development of this project to its final and complete success. In this connection as I now see it, more individual tree records in bearing orchards, and the planting of young orchards in such a way that progeny records can be secured, are the most important matters for consideration.

We would like the opportunity of consulting with prospective planters in order that we may help them plan the arrangement of progeny planting in the orchards. This most important work has to be done when the orchards are planted. There are no disadvantages in the progeny form of planting. It lays the foundation for a steady and sound improvement of our varieties through progeny studies. In my opinion it is the most effective way through which bud selection work for the amelioration of our citrus fruits can be conducted. Therefore, the citrus planters who co-operate in this work will not only secure advantages accruing from this work, but will contribute directly and effectively to the future success of our industry. We ask for the co-operation of the members of the Lemon Men's Club in this far-reaching and fundamental effort.

We are ready and anxious to co-operate in all such work. It pays, not only individually but from the viewpoint of the progress of this industry as a whole. With concentrated effort and sustained interest on the part of every one concerned, I am convinced that much greater progress is probable during the next ten years than has been possible during the past ten years of pioneer effort.

Varieties at Kilauea.

KILAUEA EXPERIMENT 28, 1922 CROP.

In this experiment, plant Yellow Caledonia cane produced more sugar than either D1135 or Badila. D1135 yielded more cane than Caledonia but, due to poorer juices, less sugar. Badila had slightly better juice than Caledonia, but this gain was more than offset by the larger tonnage of cane in the Caledonia and D1135 plots. All the cane was affected by rats, but the Badila suffered far more in this respect than did the other varieties.

VARIETY TEST
Kilauea S.P. Co. Exp. 23, 1922 Crop
Field 37.

1.1 Y.C. 34.35	1.2 Badila 24.02	1.3 D1135 32.94	1.4 Y.C. 30.94	1.5 Badila 25.90	1.6 D1135 38.99	1.7 Y.C. 35.35	1.8 Badila 28.49
2.1 D1135 36.24	2.2 Y.C. 30.09	2.3 Badila 26.85	2.4 D1135 36.85	2.5 Y.C. 36.02	2.6 Badila 28.36	2.7 D1135 35.74	2.8 Y.C 34.55
3.1 Badila 28.14	3.2 D1135 35.55	3.3 Y.C. 32.60	3.4 Badila 34.70	3.5 D1135 31.57	3.6 Y.C. 34.47	3.7 Badila 26.43	3.8 D1135 34.05
4.1 Y.C. 31.77	4.2 Badila 26.27	4.3 D1135 43.30	4.4 Y.C. 39.63	4.5 Badila 26.63	4.6 D1135 40.53	4.7 Y.C. 35.14	4.8 Badila 31.02

Ditch

Summary of Results

Variety	No. of Plots	Yields Per Acre		
		Cane	Q.R.	Sugar
Badila	11	27.90	8.45	3.30
Yellow Caledonia	11	34.08	8.52	4.00
D1135	10	35.67	10.30	3.55

The soil in the field in which these varieties were planted is heavy and comparatively unproductive. Previous to planting, the entire field received a uniform dose of stable manure and sand. One thousand pounds of reverted phosphate were placed in the furrow with the seed. All plots received uniform doses of nitrogen totalling about 150 pounds per acre.

The varieties were planted August, 1920. The Badila seed was spaced about three inches. The Caledonia seed was planted end to end and the D1135 seed was lapped about one and a half. The harvesting results follow:—

Plots	Cane	Q. R.	Sugar
Caledonia	34.08	8.52	4.00
D 1135	36.57	10.30	3.55
Badila	27.90	8.45	3.30

The Badila cane seems to ratoon very well in this section, probably even better than Caledonia or D1135, so the continuation of this experiment on the ratoon crops will be very interesting to watch.

DETAILS OF EXPERIMENT.

Object—

To determine the most profitable variety of cane to raise on the heavy mauka soils of Kilauea.

Crop—

Badila, Caledonia and D1135 plant cane.

Location—

Field 37.

Layout—

Number of plots—32.
Size of plots—1/10th acre (80.6′ by 54′).
Plots consist of 12 straight lines each 80.6′ by 4.5′.

Plan—

PLOTS.	NO. OF PLOTS.	NITROGEN.	REV. PHOS.
Badila	11	150	1000
Caledonia	11	150	1000
D1135	10	150	1000

Experiment planned, laid out and harvested by J. H. Midkiff.
Juice analyses by R. Spreckles.

J. H. M.

Mole Cricket Injury at the Manoa Substation.

By O. H. Swezey.

On November 4, 1922, my attention was called to the injury done by the mole cricket (*Gryllotalpa africana*) to seed cane planted in a newly cleared field at the Manoa substation. I visited the place with Y. Kutsunai and made observations on the extent and nature of the work done by this insect.

The field was nearly an acre in extent, and is situated in the midst of a grassy region where there is also much honohono, in a wet region near a small stream, and just beyond the other cane fields at the substation. It had been cleared up but a short time previously and had been planted almost immediately thereafter. In the planting each seed used had three eyes, but the two end eyes had been gouged out purposely, leaving only the middle one to grow. When the new shoots appeared above ground, the stand was so thin that, digging to ascertain the cause, the work of the cricket was revealed. Where no shoot had appeared above ground, the eye had been eaten out by a mole cricket. So many of these had been eaten that there was a stand only of twenty per cent. Some shoots had started and then had been gnawed into near the base so that they died.

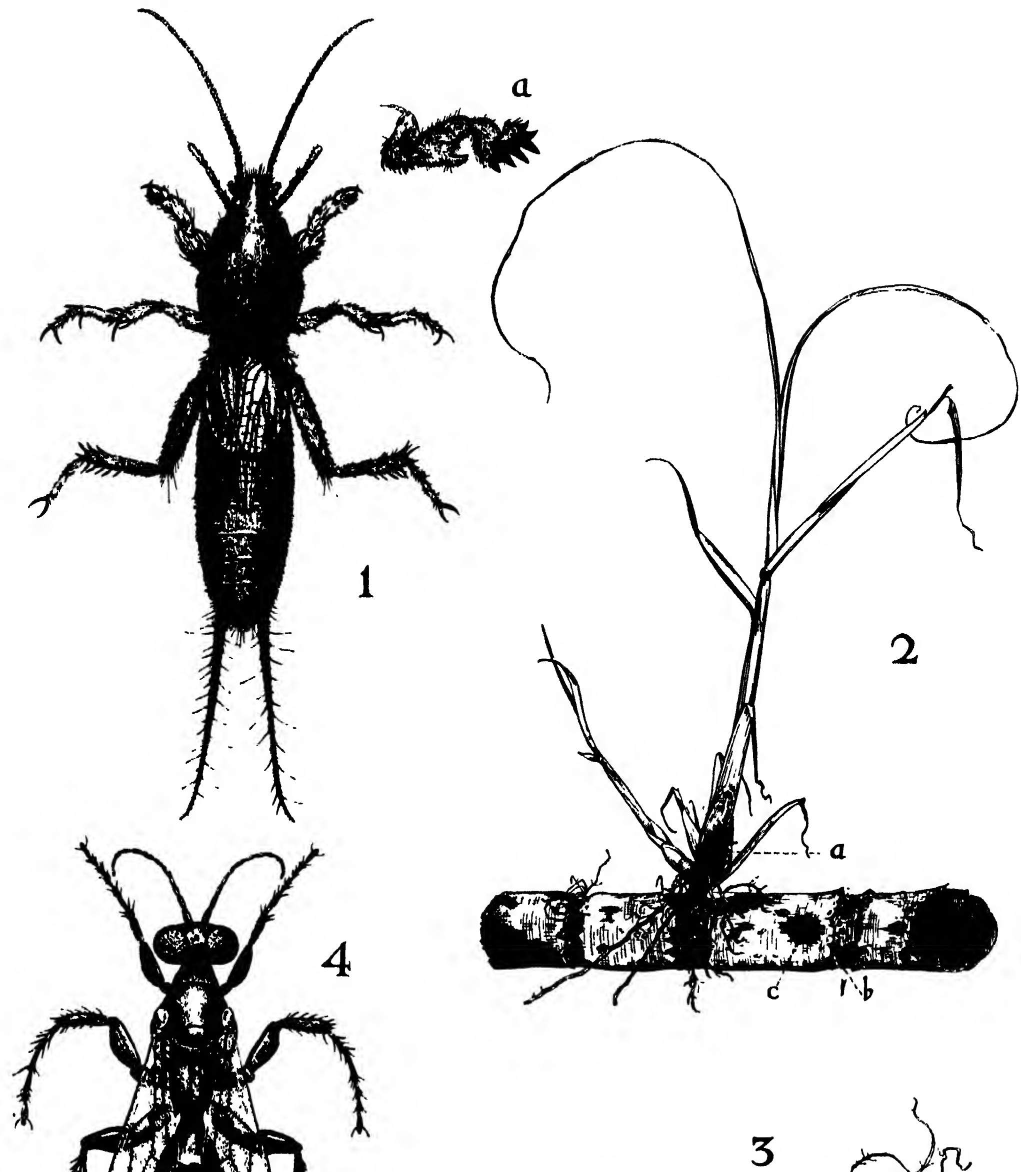
The injury by the crickets was not confined to the eyes, but the root-bands were gnawed off as well, and holes were eaten through the rind into the interior of the seed. These were of varying depths, from just starting to all the way through. They also ate into the ends of the seeds, usually completely excavating clear to the nodal tissue, and sometimes even penetrating this and traversing the full length of the seed.

In examining this work it was sometimes found that half a dozen successive seeds were entirely destroyed. The crickets were found in burrows alongside of the seeds, or nearby. They were all adults.

This is the first time that we have observed so great injury by the mole cricket in the Hawaiian Islands. The insect has been known on Oahu for a long while. It was first found on Kauai at Waimea in March, 1917. It is not yet known to the entomologists on the other islands. Heretofore its presence has been known at times in wet places on all the plantations of Oahu. The injury to the cane has been done chiefly by the crickets eating into the canes that were lying on the ground in wet places, and at times to a slight extent by eating out eyes of recently planted cuttings. Then, too, cause of complaint has been found due to the crickets burrowing into irrigation ditch banks, causing seepage and loss of water to the adjoining fields.

A mole cricket of a different species occurs in Porto Rico and the West Indies, where it is one of the serious pests. In Porto Rico the best control measure in cane has been to plant the seed leaving on the leaf sheaths, and placing it in a slanting position so that one or more eyes are above the surface, afterwards hilling slightly when the new shoots are started.

In various parts of the world there are wasps which prey on mole crickets. F. X. Williams found two of these in the Philippines in 1921 and endeavored to introduce them into Hawaii. About one dozen adult wasps were liberated at the Manoa substation. No evidence of their having become established has been observed.



MOLE CRICKET AND INJURY TO CANE "SEED."

1. Adult Cricket, × 2.
1a. Front leg showing modification for digging, × 3.
2. Cane "seed" showing injury by mole cricket, × 1/3.
2a. A young shoot has been eaten into and killed, and another new shoot has started below and at the left.
2b. Where an eye has been eaten out. The root-band has also been gnawed.
2c. Hole eaten through the rind.
3. A much eaten "seed," partially sectioned to show internal injury, × 1/3.
4. A Philippine wasp parasitic on the mole cricket, × 3½.

Points of Accuracy in Sucrose Determinations in Waste Molasses.

By H. A. Cook.

Influence of Zinc Dust on Volume of Solution for Invert Reading.

When the Hawaiian Chemists' Association adopted the new and simplified inversion method for the determination of sucrose in molasses and other sugar products, as proposed and worked out by Herbert S. Walker, supplimentary insruction sheets were sent out from this station. These instructions read in part as follows:

Pippette 75 cc. of the original filtrate into a 100-110 cc. flask, add 2 cc. 1-1 hydrochloric acid, mix, introduce a thermometer into the flask, which is then placed in a water bath heated to 70°-73° C. Shake occasionally till the thermometer in the flask indicates 65°-67° C. Remove from the bath and add 10 cc. 1-1 HCL. Allow the flask to stand at room temperature for half an hour or longer; add a little more zinc dust than is necessary to precipitate the lead, cool to the temperature at which the direct reading was made, and make up to 110 cc. with water at the same temperature. Mix thoroughly, filter and read the solution in a 200 mm. water-jacketed tube, noting the temperature accurately, which should be within one degree of that for the direct reading.

In the original work of Mr. Walker the directions read:

Allow the flask to stand at room temperature for half an hour or longer, cool to the temperature at which the direct reading was made and make up to 110 cc. with water at the same temperature. Mix thoroughly, add a little more zinc dust than is necessary, etc.

It is noticed that in the original case the zinc dust was added after the solution was made up to the required volume. Adding the zinc dust before making to the required volume will necessarily change the volume of the solution in the flask. How much of a change depends upon the amount of zinc dust added. The question has been raised several times as to how much this will influence the result of the sucrose determination.

Some time ago I made a few analyses on molasses in connection with my routine work on the above question. The results are as follows:

Sample No.	Direct Reading	Invert Reading (1)	T°C.	Invert Reading (2)	T°C.	Sucrose % (1)	Sucrose % (2)	Difference
1	31.32	—16.73	26.9	—16.77	27.0	37.38	37.42	0.04
2*	27.87	—16.40	27.1	—16.72	26.8	34.47	34.67	0.20
3	28.72	—14.93	27.0	—15.01	26.8	33.97	34.00	0.03
4*	28.76	—17.23	27.4	—14.57	27.7	35.84	35.96	0.12
5*	30.35	—17.65	27.1	—16.60	26.5	37.37	37.50	0.13
6	30.20	—14.56	27.3	—14.57	27.3	34.87	34.88	0.01
7*	27.47	—17.53	27.4	—17.68	27.8	35.07	35.24	0.17
8	25.26	—15.12	27.5	—15.15	27.8	31.48	31.54	0.06
9*	24.13	—17.72	27.3	—17.75	27.4	32.61	32.64	0.03
10*	25.89	—14.88	27.4	—15.09	27.2	31.78	31.91	0.13
					Average	34.48	34.57	0.09

*Very dark solutions requiring large amounts of zinc dust.

Invert Reading (1)=Adding requisite amount of zinc before cooling and making to the mark.

Invert Reading (2)=Adding the requisite amount of zinc after cooling and making to the mark.

Sucrose (1)=Adding requisite amount of zinc before cooling and making to the mark.

Sucrose (2)=Adding requisite amount of zinc after cooling and making to the mark.

The foregoing results show that the zinc should in all cases be added after the solution has been cooled, made to the proper volume and thoroughly mixed. However with the exception of the two results with the greatest difference, 0.20 and 0.17, the results are as close as any method can be expected to check on a product like molasses. Even in these two instances the results are as close as it is often possible to come on very dark solutions such as these were.

The difference in sucrose results shown above will make a difference in the gravity purity of the molasses as follows: Taking a brix of 88.5 and the sucrose showing the greatest difference, i. e., 0.20, there will be a difference of 0.23 in the gravity purity. Using the average difference in sucrose results, i. e., 0.09, there will be a difference of 0.10 in the gravity purity.

INFLUENCE OF VARYING AMOUNTS OF ALUMINUM SULFATE ON THE DIRECT READING IN SUCROSE DETERMINATION.

From Browne's Handbook of Sugar Analysis the following is taken:

ACTION OF LEAD SUBACETATE ON ROTATION OF FRUCTOSE.

While the specific rotation of sucrose under the ordinary conditions of analysis is not modified sufficiently by subacetate of lead to introduce serious errors, the case is otherwise with fructose. Gill first showed, in 1871, that the specific rotation of fructose was greatly diminished by the presence of subacetate of lead, this decrease being so great that in the presence of sufficient basic lead the rotation of invert sugar ($[\alpha]^{20}_{D} = -20$) was changed to the right. This change in rotation is due to the formation of soluble dextrotary lead fructosate, the presence of which even in small amounts is sufficient to reduce the figure for the rotation of fructose ($[\alpha]^{20}_{D} = -92$) below that of glucose ($[\alpha]_D = 52.5$).

I had occasion to verify the above in a series of sucrose determinations on molasses. The volume of solution used for the direct reading was changed from 50-55cc. to 100-110cc. without making sufficient increase in the amount of aluminum sulfate added. The sucrose results obtained were all high.

To show the effects of varying amounts of aluminum sulfate the following readings were made on the same filtrate varying the dilution and the amount of aluminum sulfate added:

1. 50cc. filtrate, 1cc. aluminum sulfate, diluted to 55cc reading=12.28
2. 50cc. filtrate, 2cc. aluminum sulfate, diluted to 55cc. reading=11.95
3. 50cc. filtrate, 5cc. aluminum sulfate, diluted to 55cc. reading=11.96
4. 100cc. filtrate, 2cc. aluminum sulfate, diluted to 110cc. reading=12.32
5. 100cc. filtrate, 3cc. aluminum sulfate, diluted to 110cc. reading=11.95
6. 100cc. filtrate, 4cc. aluminum sulfate, diluted to 110cc. reading=11.95

The following table gives comparisons of the sucrose results using the two different volumes and different amounts of aluminum sulfate:

Sample No.	Dilution.	No. cc. Aluminum Sulfate	Readings Direct	Readings Invert	Temperature Degrees C.	Sucrose
1	100-110	2	12.16	—5.77	27.7	30.99
1	50- 55	2	11.95	—5.77	28.0	30.68
1	100-110	3	11.95	—5.77	28.0	30.68
1	100-110	4	11.95	—5.77	28.0	30.68
2	100-110	2	13.63	—5.80	28.6	33.46
2	100-110	4	12.53	—5.98	27.4	31.95
2	100-110	5	12.53	—5.98	27.4	31.95
3	100-110	2	14.24	—6.24	27.5	35.18
3	100-110	4	13.21	—6.34	27.9	33.85
3	50- 55	2	13.14	—6.34	27.9	33.73
4	100-110	2	17.28	—5.68	29.5	39.10
4	100-110	5	17.17	—5.73	28.3	38.82
4	50- 55	2	17.22	—5.73	28.3	38.89
4	50- 55	3	17.16	—5.73	28.3	38.79
5	100-110	2	14.08	—6.75	27.5	35.99
5	100-110	4	12.90	—6.98	28.2	34.74
5	50- 55	2	12.90	—6.98	28.2	34.74
6	100-110	2	13.01	—6.07	27.8	32.95
6	100-110	4	12.13	—6.30	27.8	32.06

It is thus shown that it is essential that sufficient aluminum sulfate be added to restore the specific rotation of the fructose. It is shown that for a volume of 50cc. diluted to 55cc. it requires 2cc. of a saturated solution of aluminum sulfate, and for a volume of 100cc. 4cc. of the aluminum solution is required. A little more does not influence the results.

Influence of the Temperature on Inversion in Sucrose Determinations.

In using Herzfeld's modification of the Clerget method of analysis of sucrose it has always been maintained that in order to secure correct results it was necessary to follow very closely the details of procedure. This is especially true in regard to the amount of hydrochloric acid added and the details of heating. This is to place the solution to be inverted into a water bath with the temperature so controlled that the solution will reach a temperature of 69°C. in 2½ to 5 minutes and maintain a temperature of between 68° and 69°C. for exactly five minutes, then cooling the solution to the required room temperature as rapidly as possible.

In Browne's *Handbook of Sugar Analysis*, page 268, we find the following:

The inversion method of Herzfeld gives correct results only when the prescribed conditions of concentration, amount of acid, volume, temperature and time of inversion are carefully followed.

In Mr. Walker's modification of the Herzfeld method considerable study and attention was given to the temperature at which the hydrochloric acid was added to the solution. In this method the temperature has considerable wider latitude than in any other method, being between 65° and 67°C.

In *Sugar,* Volume 24, May, 1922, is found the following extract:

In using Herzfeld's modification of the Clerget method in the analysis of molasses, E. Freibauer confirmed Koydl's opinion (Oesterr. Z. Zukerind, 1897, 503) that it is unnecessary to limit closely the temperature at which the inversion with HCL takes place. The same results were obtained by placing the solution to be inverted for ten minutes in a water bath previously heated to 90° C. as at 69° C.

As the above statement contradicted nearly all of the authors on the subject, I wished to test the method. Instead of using the Herzfeld modification, I used that in use by the H. C. A. which has been found in all cases to give results as close as those by the Herzfeld method. For comparison I used 75cc. of the filtrate, added 5cc. HCL Sp. Gr. 1.19, and placed the solution in a water bath heated to 90°C. for ten minutes. The results of five determinations are as follows:

Sample No.	Direct Reading	Invert Reading H. C. A. Method	Invert Reading Heating to 90°C.	Sucrose H. C. A. Method	Sucrose Frei-bauer Method	Differ-ence
1	30.35	—17.65	—16.72	37.37	36.60	0.77 Lower
2	27.47	—17.53	—15.52	35.07	33.61	1.46 Lower
3	25.16	—15.31	—15.12	31.53	31.40	0.13 Lower
4	24.13	—17.72	—16.48	32.61	31.63	0.98 Lower
5	25.89	—14.88	—14.32	31.78	31.29	0.49 Lower

The above results confirm all that has been maintained heretofore in following the details of the Herzfeld method.

Carbon Bisulfide For Cane Grubs.

Recent experiments in the use of carbon bisulfide for killing cane grubs in Queensland have proved successful, according to a report of these experiments carried on by the Colonial Sugar Refining Company at Greenhills, and reported on by E. Jarvis in the *Australian Sugar Journal,* August 4, 1922.

A photograph in the *Journal* showed a plot of Badila cane, taken a few months after treatment, in which the section treated with carbon bisulfide was nine feet high, while the untreated section was only seven feet high, due to the effect of grubs feeding on the roots. The former received one-half ounce of carbon bisulfide to each stool (one-fourth ounce on each side); otherwise the conditions and care of both plots were the same. No mention is made of the cost of this treatment, but it was considered notably successful.

It is pointed out that the carbon bisulfide should be applied as soon as it is known that grubs are present, before the cane has become affected, but not until the termination of the egg-laying period.

Mention is made of previous experiments which showed it to be possible to fumigate successfully not only the grubs, but both pupae and eggs of the grey-back cane beetle. It is said that the egg shell, although leathery in texture, is slightly porous and offers little or no resistance to the entrance of bisulfide fumes.

In an earlier report by J. F. Illingworth, published in Bulletin No. 8, Division of Entomology, Queensland Bureau of Sugar Experiment Stations, 1919, success is ascribed to the use of carbon bisulfide at Gordonvale. About the same size charge was used and when applied to both sides of the stool it resulted in a complete killing of the grubs.

In neither of the cases reported was there any mention of injury to the cane by the carbon bisulfide. In the second instance, however, Mr. Illingworth remarks that "evidently the rains which followed a day or so after the application saved the cane from any ill-effects of the chemical."

O. H. S.

Report of the Committee on Mill Equipment.*

By W. v H. DUKER.

In preparing a report for this meeting your committee has had in view the benefit derived from frequently reviewing and discussing the various improvements made in our mill equipment during the past years, and has sent out a letter requesting the various members to ask what changes have been made either by installing or discarding equipment.

It is important for all of us to know when something new comes up, and it is also of equal importance that we know when any novelty is later discarded and the reason why.

Quite a number of replies have been received which should furnish ample material for discussion.

REVOLVING KNIVES

A few years ago no season passed but a new type of knives was proposed. Lately very little has been said in this respect, and I think we are interested to know whether I am right in stating that at one time we overestimated the benefit derived from cutting up the cane very finely, and that we have now gone back to the idea that the object has been fulfilled as long as the knives are so arranged that they level the cane down so as to assure an even feed.

*Presented at the First Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, November 15-18, 1922.

SHREDDERS

Every now and then the question comes up as to whether or not the shredder is a successful part of the equipment, and if those who have installed one have found it an advantage.

I have compiled a statement giving the results obtained in the factories equipped with shredders from 1914 on.

I have compiled a statement giving the results obtained in the factories not be considered. But in practically every instance either the capacity or the extraction, or both, show an increase. This does not necessarily mean that a shredder is a desirable feature in every mill, and I think experience has shown that unless the other equipment of the factory balances with that of the mill equipment no success can be expected.

FACTORY No. 34

Crop	Equipment	Tons Cane per Hour	Dilution	Extraction
1914	Crusher 60″ 12 R. M. 66″	34.41	29.24	96.75
1915	Crusher 60″ 12 R. M. 66″	36.34	41.36	97.73
1916	Crusher 60″ 12 R. M. 66″	36.53	39.87	98.05
1917	Knives S-54″ 12 R. M. 66″	36.79	43.4	98.31
1918	Crusher 60″ S-54″ 12 R. M. 66″	37.61	42.8	98.40
1919	Crusher 60″ S-54″ 12 R. M. 66″	39.29	40.58	98.58
1920	Crusher 60″ S-54″ 12 R. M. 66″	37.03	44.08	98.61
1921	Crusher 60″ S-54″ 12 R. M. 66″	33.4	42.3	98.8

FACTORY No. 10

Crop	Equipment	Tons Cane per Hour	Dilution	Extraction
1914	Crusher 54″ 12 R. M. 72″	53.75	26.54	96.20
1915	Knives Crusher 54″ 12 R. M. 72″	55.98	34.19	96.32
1916	Knives Crusher 54″ S-54″ 12 R. M. 72″	57.12	42.38	96.72
1917	Knives Crusher 54″ S-54″ 12 R. M. 72″	59.55	38.47	97.25
1918	Knives (2) Crusher 54″ S-54″ 12 R. M. 72″	57.68	33.45	97.22
1919	Knives Crusher 60″ S-54″ 12 R. M. 72″	56.29	36.34	97.45
1920	Knives Crusher 72″ S-72″ 15 R. M. 72″	61.04	31.96	98.12
1921	Knives (2) Crusher 72″ S-72″ 15 R. M. 72″	62.77	39.5	97.84

FACTORY No. 16

Crop	Equipment	Tons Cane per Hour	Dilution	Extraction
1914	Knives Crusher 72" 12 R. M. 78"	45.61	29.33	95.57
1915	Knives Crusher 72" 12 R. M. 78"	46.61	31.40	96.14
1916	Knives Crusher 72" S-72" 12 R. M. 78"	42.51	37.43	96.25
1917	Knives Crusher 72" S-72" 12 R. M. 78"	42.27	39.92	96.91
1918	Knives (2) Crusher 72" S-72" 12 R. M. 78"	42.04	28.88	97.40
1919	Knives Crusher 72" S-72" 12 R. M. 78"	41.34	36.4	97.66
1920	Knives Crusher 72" S-72" 12 R. M. 78"	42.39	43.76	97.98
1921	Knives Crusher 72" S-72" 12 R. M. 78"	37.16	40.55	98.05

FACTORY No. 13

Crop	Equipment	Tons Cane per Hour	Dilution	Extraction
1914	Knives Crusher 78" 9 R. M. 78"	40.02	30. 36	94.48
1915	Knives Crusher 78" 9 R. M. 78"	39.95	35.0	95.80
1916	Knives (2) S-54" 11 R. M. 78"	39.37	50.43	97.49
1917	Knives (2) S-54" 11 R. M. 78"	39.0	48.2	97.44
1918	Knives (2) S-54" 11 R. M. 78"	39.4	49.9	97.26
1919	Knives (2) S-54" 11 R. M. 78"	38.43	47.6	97.28
1920	Knives (2) S-54" 11 R. M. 78"	34.76	48.84	96.65
1921	Knives (2) S-54" 11 R. M. 78"	33.3	57.2	97.00

(1920 and 1921, years of labor strike and shortage factory operated entire year.)

FACTORY No. 6

Crop	Equipment	Tons Cane per Hour	Dilution	Extraction
1914	Knives Crusher 72" 12 R. M. 78"	52.94	33.66	95.57
1915	Knives Crusher 72" S-54" (part of year) 12 R. M. 78"	53.76	35.98	97.32
1916	Knives Crusher 72" S-72" 12 R. M. 78"	55.6	40.27	97.73
1917	Knives (2) Crusher 78" S-72" 12 R. M. 78"	59.6	35.18	98.56
1918	Knives (2) Crusher 78" S-72" 12 R. M. 78"	55.37	39.18	98.47
1919	Knives (2) Crusher 78" S-72" 12 R. M. 78"	48.25	50.64	98.99
1920	Knives (2) Crusher 78" S-72" 12 R. M. 78"	58.08	43.93	98.92
1921	Knives (2) Crusher 78" S-72" 15 R. M. 78"	67.27	36.6	99.07

FACTORY No. 27

Crop	Equipment	Tons Cane per Hour	Dilution	Extraction
1914	Knives Crusher 72" 9 R. M. 78"	36.71	30.8	94.0
1915	Knives Crusher 72" 9 R. M. 78"	37.84	26.6	94.3
1916	Knives Crusher 72" 9 R. M. 78"	35.51	34.3	95.28
1917	Knives Crusher 72" 9 R. M. 78"	34.83	40.89	96.34
1918	Knives Crusher 72" 12 R. M. 78"	44.19	32.4	96.51
1919	Knives Crusher 72" 12 R. M. 78"	36.57	38.79	95.77
1920	Knives Crusher 72" S-72 12 R. M. 78"	45.15	31.86	97.25
1921	Knives Crusher 78" S-72 12 R. M. 78"	45.03	27.37	97.10

FACTORY No. 36

Crop	Equipment	Tons Cane per Hour	Dilution	Extraction
1914	Knives 3 R. Cr. 78″ 9 R. M. 78″	48.2	32.6	95.19
1915	Knives 3 R. Cr. 78″ 9 R. M. 78″	46.5	27.9	96.10
1916	Knives 3 R. Cr. 78″ 9 R. M. 78″	43.5	24.8	95.54
1917	Knives S-72″ 12 R. M. 78″	58.7	31. 3	96.56
1918	Knives S-72″ 12 R. M. 78″	53.7	29.0	96.60
1919	Knives S-72″ 12 R. M. 78″	49.64	33.8	97.32
1920	Knives S-72″ 12 R. M. 78″	49.56	35.3	96.94
1921	Knives S-72″ 12 R. M. 78″	48.33	32.1	96.83

The increased capacity does not show up in the last three years, but in this case this is due to droughts which caused a lack of flume water; the mill did not grind steadily, etc.

MILLS

The steel rollers which were once thought to solve the problem of the frequently reshelling or renewing of rollers have apparently lost out, but the following letter by Mr. Renton is instructive to show that the Hind-Renton-grooving after all has been responsible for the introduction of the deep grooving, now found in many mills as a means to facilitate feeding.

Mr. Renton writes as follows:

One Steel Feed Roller, 34 inches in diameter, 1 inch pitch grooving of 30° angle, was installed in No. 4 mill as a feed roller on December 1, 1914, and the crop started a week later.

This roller has been in continuous use since that date and is now in use completing its eighth crop. It is now 32 inches in diameter and will probably be scrapped this off-season.

No. 4 mill is favorably situated in that the blanket from No. 3 mill of the first mill train passes through long conveyors and is tumbled around considerably before being spread in front of No. 4 mill of the second mill train.

The No. 4 mill with the steel roller has never refused to feed even when returning a considerable quantity of No. 4 expressed juice in front of the fourth mill as well as all of No. 5 expressed juice.

One other new steel roller of ¾ inch pitch, otherwise same as above, is now on hand and was tried out as a feed roller in the sixth mill for the first two weeks of the 1916 crop, but with poor success as it did not feed well. It might be argued that the pitch being ¼ inch less might affect the results, but I am inclined to believe that the size of the fibers in the blanket being short did not give it the necessary gripping effect. Needless to say it was a failure in the sixth mill.

During the last several years conditions have not permitted the experimenting further along this line, but it is my intention to install this new steel feed roller at an early date,

if possible, in some mill ahead of the fifth and then I will be in a position to furnish further information.

Regarding the "Hind-Renton Grooving" of which you make inquiry, I would say that in a measure, it is still with us. In order to feed the necessary tonnage here at Ewa, we departed from the old 1/8 inch pitch standard to 3/8 inch pitch throughout. Later the feed rollers were increased in pitch to 3/4 inch with still better results in capacity. We are now going back to the fine grooving in top and back rolls, but retaining the 3/4 inch pitch feed rolls as well as juice grooves in the feed and back rolls. I believe this last combination is being adopted by all factories grinding large tonnage of cane.

The Hind-Renton grooving is responsible for the introduction of the coarse grooving.

Mill-cheeks: There are still undesirable features in the present design of the mill cheeks, and particularly in the fact that only a small margin of roller wear is possible.

Some years ago 33 inch diameter rollers were used, or recommended for use, to take the place of the regular 32 inch rollers. Perhaps some of the engineers present can give us information as to the success or failure of this experiment.

Intermediate carriers: A new departure in this has been the introduction of the Meinecke chute, the construction of which is of course now known to every one, and as far as I know it has given full satisfaction wherever installed.

Mill beds and cush-cush: Our problem of disposing of the cush-cush is still with us in the mills that have the old style mill beds. When we speak of this cush-cush we mean the coarser material. The finer particles, which come under the name of suspended matter, are now receiving more and more attention since the general opinion now prevails that it is these fine particles which cause so much of the stickiness and gummyness of our after products.

Mr. H. C. Welle, Chief Chemist for the California & Hawaiian Sugar Refinery Corporation, in a recent report on the qualities of raw sugars, writes:

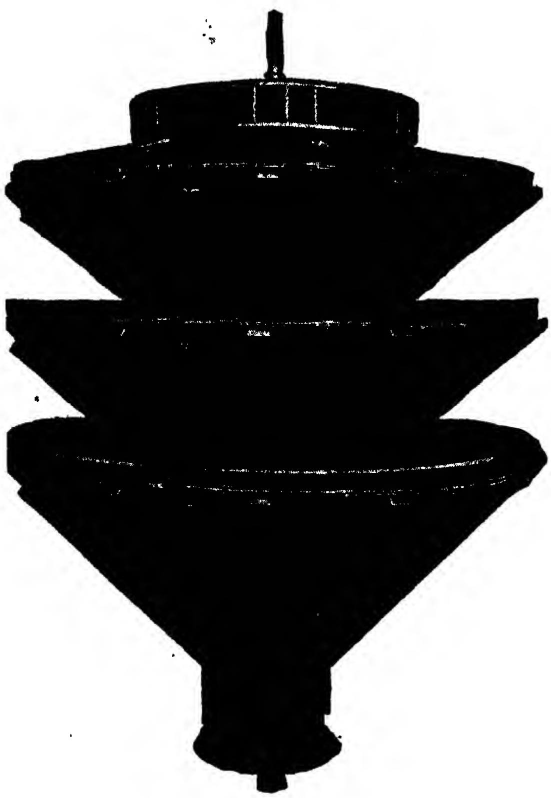
Another phase that possibly may be of greater interest to the refiner is the probability that the extensive milling disintegrates the fiber of the cane to such a degree as to make it much more difficult to remove the so called "cush-cush" by means of screens, than would be the case with more moderate milling.

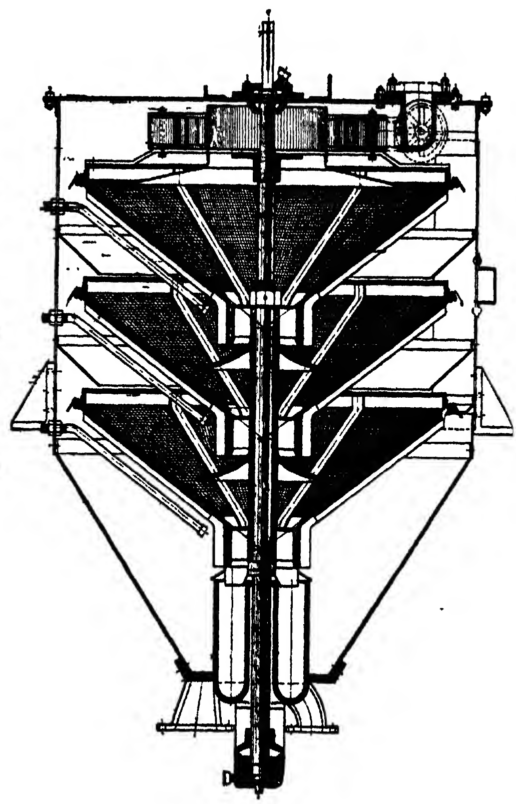
It is purely surmise, but based on various definite observations, that this extremely finely divided solid material in suspension, when treated with lime at the high temperature of the tubular heaters, is changed or partially changed into a gummy material such as dextran.

In most cases the low grade products were noted to be very gummy indeed, and it may be that this theory may partly account for such a fact.

A device designed by Mr. S. S. Peck is now in operation in one of the factories on this island. Another screening device has been mentioned in the sugar journals and is of the following description:

A test of the Carter Automatic Juice Strainer manufactured by the Horton-Brown Corporation, 149 Broadway, New York City, was recently made in connection with the straining of cold cane juice, and some interesting data secured as a result. One of these machines was installed by the West Indian Sugar Finance Corporation at its Central Consuelo in the Dominion Republic for the purpose of operating on the cold juice. Since 1916 this factory has been using a Carter Automatic Juice Strainer on hot juice with great success, handling the entire output of the factory with a grinding capacity of 2,800 tons of cane per day.





This season it was decided to try one of these machines on the cold juice. The test was successful. One hundred thousand bags of sugar have been made to date.

The juice, for convenience in testing out this machine on cold products, is weighed and limed first. The common receiving tank from the scales is used as the supply for the strainer which is situated on the same floor as the juice heaters. The juice flows by gravity from the supply tank, 8 feet 5 inches above the inlet nozzle on the strainer, driving the machine 40 r. p. m.

The suspended matter removed from the juice flows by gravity through the mud pipe beneath the strainer, from which it is pumped through the heaters.

The suspended matter removed from the juice flows by gra' ity through the mud pipe at the bottom of the strainer to the mud canal under the defecators, with the volume of a one-inch pipe of juice escaping with it. This small volume of unstrained juice passes over the screen surface and keeps them clean, at the same time conveying the separated matter wherever desired.

With this arrangement, the bagacillo passing through the mill strainer is prevented from being heated, or passing into the defecators or evaporators. Through the mud tanks, the solid matter removed by the cold strainer reaches the filter presses.

The sizing given the bagacillo after passing the final screen and the cold strainer, which has an opening of 0.0115 inch, is believed to be large enough to make a porus filtering material, which would allow the removed bagacillo to be returned to the mills.

The mill juice strainer is 12 mesh brass punched plate with 144 holes per square inch; size of opening 0.053 inch.

The Carter strainer has three sets of twilled monel metal wire cloth screens as follows: first screen, 20 mesh, holes per square inch 400, size opening .0220 inch; second screen 30 mesh, holes 900, size opening .0163 inch; third screen, 40 mesh, holes per square inch 1600, size opening .0115 inch.

Upward of 17,000 pounds of bagacillo is removed from the cold juice each 24 hours from the juice of 2800 tons of cane. Before straining the cold juice, 2500 pounds of bagacillo was being removed from the clarified juice each 24 hours on average cane, by the hot juice strainer, and much more on burnt cane.

Since installing the cold machine, the bagacillc has decreased from 2,500 pounds in the hot juice, to less than 500 pounds in 24 hours.

The percentage of mud from the defecators has decreased, much more clear juice is recovered, and the juice settles more readily. The general clarification is improved and the heaters, defecators, and evaporators are free from the scale and deposits of former years. The fabrication department can handle more juice than in former times.

The following is an extract from a letter received from The Horton-Brown Corporation regarding this strainer:

The foregoing represents the latest method for handling raw juice and takes the place of the method described on the insert in the booklet. From this you will note that the raw juice is being strained before it is limed.

A number of factories do not have sufficient head room to use a gravity drive and for these conditions different methods for operating the Carter Strainer have been developed. One method consists of a mechanical drive which is placed on the top of the strainer. This drive is made up of a bevel pinion which is fitted to the central shaft extending from the top of the strainer. The power is taken from a bevel gear mounted on a shaft running parallel to the top of the machine. On the outside end of the shaft are placed either tight and loose pulleys, to take a belt from the line shaft in the factory, or a single pulley, to take a belt from a motor.

With the above outlines, we believe you will be able to form a good idea of just what the Carter Juice Strainer may be expected to accomplish. We would like, however, for you to keep in mind that the Carter Strainer is a STRAINER and **not** a filter. We find that a great many people endeavor to make a filter out of a strainer, and by so doing spoil any good results that might otherwise be obtained.

In last year's report of this committee and on several other occasions the question was brought up: "How much of this high extraction sugar do we get in the bags?", and therefore any definite data are always taken up with considerable interest. The following is a report by J. Lewis Renton, mill superintendent, on the recent experiences at Ewa:

Unloader chain on Gregg Unloader was changed to heavier link chain of a different make, thereby reducing the delay due to the unloader from four hours per week to less than one-half hour per week stoppages for that station. The original chain was not only lighter in construction, but the material was very poor and gave trouble even when new, particularly the last new lot purchased.

Meinecke Intermediate Carriers were installed in the second nine roller mill train, or "B Mill" during the period February 14 to May 20, 1922, when this mill was shut down for repairs. Mr. Purcell, the Chief Engineer, reports that "During the thirteen weeks the new Meinecke Intermediate Carriers have been in operation no delays for

repairs or adjustments have been necessary, though a little extra attention was necessary for the first few days. Sunday work on scraper upkeep about the same as formerly."

Juice pans of an improved type were installed in this "B Mill" train during this same shut down period. These juice pans are of the deep steep-sloping side pattern being 45% slope under the back roll and sides, and 30% slope under the feed roller; the idea being that there is so much liquid expressed by the feed roller that the slope under the feed roller will be washed clean of any accumulation of cush-cush and the remaining slopes so steep that cush-cush cannot lodge on same, keeping the entire pan as sanitary as possible and eliminating any pockets or accumulations where souring might take place. Would recommend making slope under back roller still steeper than 45%. This installation is a big improvement over the juice pans previously used, and does away with one man keeping the juice pans clean.

Mr. Orth, the Chief Chemist, reports "There is considerably less difference in purities between crusher juice and normal juice, mixed juice and syrup in 1922 than in 1921 and 1919. 1921 may be considered abnormal but 1919 is regarded here as a normal year. We did have about 15% less dilution on an average so far this season and this may have some influence on the purities, but I am inclined to give most credit for the improvement to the cleaner conditions around the mill. That the differences in the figures during the 18-roller mill period this year are not larger than when grinding with a 9-roller mill is, in my opinion, in a great measure due to the new conveyors and juice pans, which can be kept clean easily."

	1922		1921	1919
	9 RM Period	18 RM Period	18 RM Period	18 RM Period
Crusher juice app. pur.	87.62	86.56	84.15	86.30
Normal juice	84.04	83.36	78.86	81.83
Mixed juice	84.70	83.82	79.37	82.61
Syrup	86.16	85.19	80.97	84.28
Cr. J. nor. juice	3.58	3.20	5.29	4.47
Cr. J. mix. juice	2.92	2.74	4.78	3.65
Cr. J. syrup	1.46	1.37	3.18	2.02

During the foregoing forced shut down of "B Mill", the second 9-roller mill train, "A Mill", continued grinding from February 14 to May 20, 1922. The equipment of "A Mill" consists of two 72 knife sets, two roller crusher 32"x78", and 9-roller mill 34"x78".

Records were kept on cost and recoveries. It was found that it cost very close to $1.00 a ton of sugar manufactured to operate the second mill train or "B Mill" and that the extra 4% higher extraction more than paid for this extra expense.

The formula used to figure out the increased return in dollars of an 18-roller mill above what would have been received if operating as a 9-roller mill was:

$$S = X\,Y - (A + B).$$

S = Increased return in dollars 18-roller mill over 9-roller mill.
X = Tons sugar recovered due to higher extraction.
Y = Dollars received per ton sugar.
A = Extra cost of manufacturing.
B = Extra cost of marketing X tons of sugar.

From the above the following table was computed for varying prices of sugar and varying syrup purities:

INCREASE RETURN IN DOLLARS OF 18-ROLLER MILL OVER 9-ROLLER MILL.

ASSUME 285,715 tons cane per crop.
14% Sucrose in cane (about 13.7 Pol'n.).
98% Extraction with 18-roller Mill.
94% Extraction with 9-roller Mill.

Price received for sugar. Dollars per Ton.	PURITY OF SYRUP				
	70	75	80	85	90
$110.00	$87,604.	$94,315.	$99,758.	$105,004.	$109,339.
100.00	75,826.	81,640.	86,342.	90,886.	94,636.
90.00	64,048.	68,965.	72,926.	76,768.	79,933.
80.00	52,270.	56,290.	59,510.	62,650.	65,230.

Mr. Nolan, the Sugar Boiler, states that "during the 9-roller period, one crystallizer was filled for each 63.9 tons of sugar bagged, and during the 18-roller mill period, one crystallizer was filled for each 57 tons of sugar bagged. He also reports that during the 9-roller mill period the evaporators were cleaner, requiring only one gang of five men for each Sunday, as compared to two or three gangs of five men each when running an 18-roller mill. He further reports that the boiling of both first and second sugars was easier during the 9-roller mill period. No noticeable change was observed in clarification when we changed from a 9-roller to an 18-roller mill or in the mud press station."

The tons sugar recovered due to higher extraction was computed from data obtained during the 9-roller mill period from February 14 to May 20, 1922, as compared with the 18-roller mill period from May 20 to July 22, 1922.

The gravity purity of the waste molasses was the same in both cases, namely 37.12. The tons of waste molasses per ton sucrose in sugar for the 9-roller mill period was 0.255 and for the 18-roller mill 0.236. This slight difference may be an error in estimating molasses in stock and, for this experiment, may be considered the same.

Sucrose balances for the two periods mentioned above are enclosed for those interested.

SUCROSE BALANCE

	9-roller mill period February 14 to May 20, 1922.						18-roller mill period May 20 to July 22, 1922.					
	Tons	% Sucrose	Sucrose % Cane	Sucrose % Sucr. in Cane	Sucr. % Sucr. in Mix. Juice	Tons Sucrose	Tons	% Sucrose	Sucrose % Cane	Sucrose % Sucr. in Cane	Sucr. % Sucr. in Mix. Juice	Tons Sucrose
Cane	100,791.54	13.34	....	100	....	13,370.59	62,981.79	14.26	14.26	100	....	8,980.39
Mixed juice	112,469.35	11.18	12.55	94.07	100	12,578.06	72,020.73	12.22	13.97	97.98	100	8,799.20
Bagasse	24,865.02	3.19	0.79	5.93	....	792.53	13,069.04	1.39	0.29	2.02	....	181.19
Press cake	1,946.62	1.31	0.02	0.19	0.21	25.47	1,535.31	0.91	0.02	0.16	0.16	14.00
Waste molasses	2,941.12	32.34	0.95	7.11	7.56	951.11	1,895.98	33.27	1.00	7.02	7.17	630.82
Undetermined	....	....	0.07	0.50	0.53	67.08	....	....	0.17	0.17	1.19	105.20
Total losses	....	....	1.83	13.73	8.30	1,836.19	....	....	1.48	10.37	8.52	931.21
Commercial sugar, recovery	11,866.07	97.20	11.51	86.27	91.70	11,534.40	8,277.53	97.24	12.78	89.63	91.48	8,049.18
Commercial sugar, to date, Gr. Pur.						98.59						98.75
Syrup to date, Gr. Pur.						86.89						86.17
Waste molasses to date, Gr. Pur.						37.12						37.12
Theoret. B. H. recovery	98.59 (86.89—37.12) / 86.89 (98.59—37.12)					91.87						91.21
Theoret. molasses loss						8.13						8.79
Act. % theoret. B. H. recovery	(91.70 × 100) : 91.87					99.82						100.30
Act. % theoret. molasses loss						92.99						81.57
Sucrose accounted for per 100 obtainable sucrose	11,534.40:(12,578.06—25.47) × 91.87					100.01	8049.18 (8799.20—14.00) × 91.21					100.45
Based on normal juice plus (Gr. Pur. Syr.—Gr. Pur. Mix. J.) Factory efficiency number	86.27 × 100 / 91.39					94.40	89.63 × 100 / 91.09					98.40
Based on 100 extraction and 35 gr. pur. waste molasses	Factory efficiency 1921					94.23						

Comparison of	9-Roller Period and	18-Roller Period
Theoretical boiling house recovery*..............	91.85	91.28
Extraction	94.07	97.98
Actual boiling house recovery....................	91.70	92.05
Total recovery	86.26	90.19
Gain in extraction..............................	....	3.91
Gain in total recovery..........................	....	3.93

*Sugar purities were equalized (98.62). Molasses purities happened to be alike, so that the difference of 0.57 is due *only* to difference in syrup purities. This 0.57 is added to the actual boiling house recovery in the 18-roller period to make the figures comparable with the 9-roller period.

Mr. Herbert Walker, Superintendent of Pioneer Mill Company, adds the following:

The new equipment put in at Pioneer for the 1922 crop was, two calandria pans, 1400 cubic feet, 1700 square feet h. s. each, a separate juice strainer and cush-cush returned for the fifth mill, and a Meinecke type intermediate conveyor between the first and second mills.

The new pans have been a great help to us in several respects. The extra heating surface allows us to boil entirely with exhaust steam except for about half an hour when boiling down. Dividing the number one sugar pans in three units instead of two keeps at least one pan going all the time and helps balance the demand for steam, so that we are able to utilize all the exhaust from the mill engines and the turbine even when generating more electric power than the mill needs. The exhaust pressure has been reduced to between 0 and 4 pounds. The installation of these pans seems to have been the finishing touch needed to complete our steam economy program, and for the first time on record we have gone through a season without burning extra fuel. I think the new evaporator put in for 1921 was probably needed more than the pans, but the combination was necessary to get the best results. The additional equipment released for low grade work the large pan formerly used for commercial sugar, and, given more time for boiling, the low grade grain was increased to an average of .3 to .5 mm., about double the former size, which made it possible to dry all our massecuite without dilution or heat and resulted in a much lower waste molasses purity. The shipping sugar grain was also increased in size to about 10% ''total small''. I have not heard whether or not this was considered an improvement.

The separate cush-cush returning system for the last mill helped to reduce the maceration needed without sacrificing extraction. It also reduced very slightly the amount of suspended solids in the mixed juice.

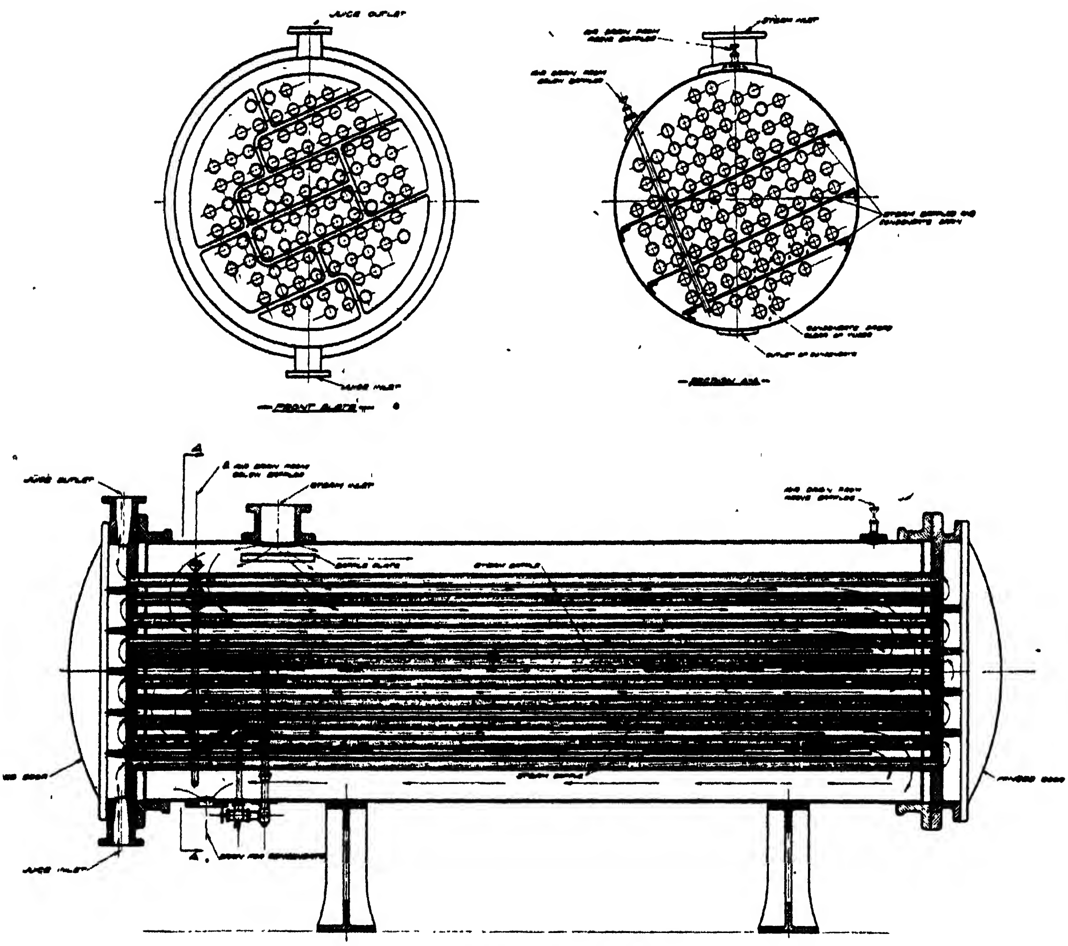
In my report to you last year I suggested that experiments be carried out to determine how much sugar actually could be obtained from last mill juice under conditions of high extraction, high ash and low glucose. Results obtained here during the 1922 crop indicate that a low glucose—ash ratio does not of itself prevent crystallization down to a fairly low purity molasses. During a period of several weeks our waste molasses averaged less than 34 gravity purity and contained more ash than glucose.

JUICE HEATERS.

Mr. E. Kopke of the Honolulu Iron Works, who is the author of several interesting articles and studies on this subject, described a newly designed heater in a report last year to the H. S. P. A. Because the Mill Engineers' Association has had no regular meeting during the last two years, this information might have escaped the attention of many and is therefore incorporated in this report.

In practice is it found that the maximum capacity of this type of heater may be taken at 60 pounds of juice per hour per square foot of heating surface, when the juice velocity through the tubes is about 6 feet per second and the steam pressure on the body about 4 pounds per square inch and the juice temperature rises from 80° to 212° F.

The capacity of any heater or what is the same thing, a surface condensor, depends upon:

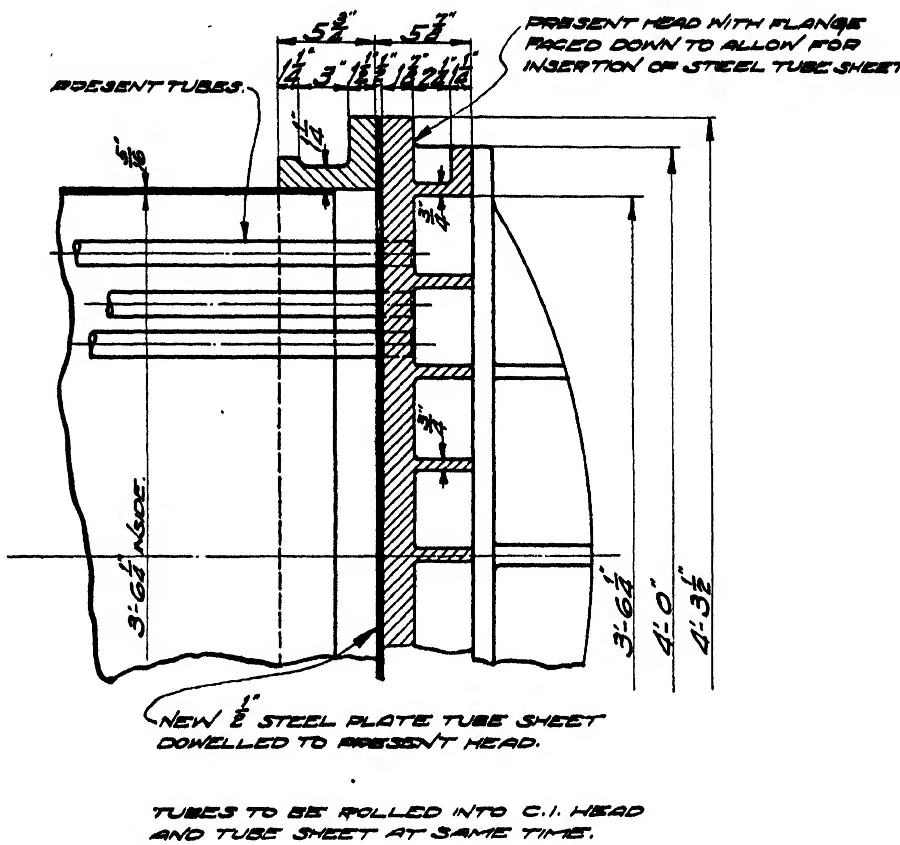


GENERAL ARRANGEMENT
OF
SPECIAL INCLINED BAFFLE JUICE HEATER

1. The actual temperature difference between the steam and juice.
2. The conductibility of the dividing partition (heating surface).
3. The voidance of the condensate that forms on the heating surface.
4. The velocity with which the juice flows along the heating surface on the other side.

The improvements of the juice heater under consideration, made by the Honolulu Iron Works, are diagrammatically illustrated herewith. It accomplishes two things: Voiding the condensate as it forms over the tubes, and bringing about a decided steam velocity along the tubes. The direction of the steam flow is practically counter-current to the flow of the juice.

Referring to the cuts, the front plate shows the lay out of the tubes. The rows of tubes are slanting. Section A A shows the arrangement of tubes as shown in the front plate and the steam baffle, condensate drain plates, bottom and top air vent, also the steam inlet nozzle and condensate outlet. Fig. H is a diagrammatical length section of the heater.



The steam enters through the upper nozzle in the comparatively large space of the cell above the upper slanting steam baffle or condensate drain plate. The plate is placed close against the head nearest the steam inlet nozzle, but leaves an open space between it and the opposite head. The steam is induced to flow, as indicated by the arrows, along the upper bank of tubes, and to turn at the end of the plate down into the next lower space. This flowing to and fro of the steam is repeated as often as there are plates in the cell until it is condensed and flows off through the condensate outlet.

The comparatively high steam velocity induced by the partitioning with baffle plates aids the separation of condensate from the tubes. The drip from the upper bank of tubes falls on to the slanting plate, and is delivered to the shell of the heater away from the next lower one. Between the edge of the plate and the shell is ample space to allow the condensate to flow through. The same occurs, of course, in the rest of the compartments until the outlet is reached.

Another important feature embodied in this design is that the baffle plates are placed so that the cross sections of the different compartments decrease in area from the top down. The steam is reduced in volume through loss of heat from one compartment to the next, but an approximately even steam velocity is maintained.

The sum of these changes in design from the old one has invariably increased the capacity of the heater per square foot heating surface 100%. This has been shown in numerous installations in Cuba, and also in the first one here in Hawaii.

In recent years quite a few of the juice heater juice heads used to crack, as well as the doors. Whether this breaking is due to faulty design or to careless operating has been the subject of dispute many times.

The sketch submitted here, and contributed by Mr. A. Ewart, shows a new method of repair or rather a way to eliminate the danger of juice getting into the steam space. A one-half inch steel plate is placed right back of the tube-head which latter part must first be planed and the steel plate made a close fit.

Still another type of juice heater is the one illustrated on next page and designed by Mr. T. Terry, who writes as follows:

The chief points of attraction in this design of juice heater are:

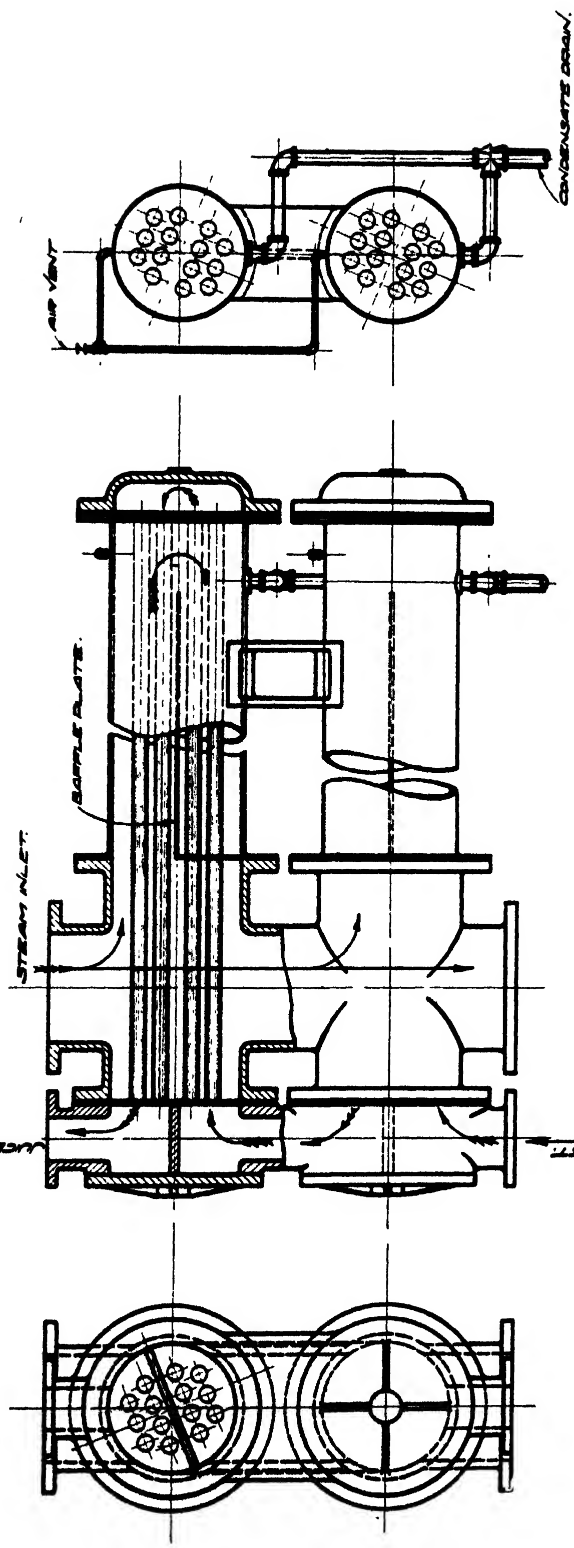
1. The counterflow principle between the juice in the tubes and the steam outside is 100%.

2. The condensate is drained rapidly from each group of tubes and is thus eliminated from interfering with the efficiency of other tubes.

3. All tubes are equally supplied with the available steam directly from the supply manifold.

4. The square feet of heating surface can be increased when necessary by purchasing extra sections.

5. The covers and heads are not subject to breakage and yet can be removed easily for cleaning.



PROPOSED JUICE HEATER.

SCALE 1½"=1'-0"

OCT. 9-1922

CLARIFICATION.

Ever since the news passed around that two of the largest factories had decided to adopt the Thomas and Petree process, a keen interest is felt in the exact construction and mode of operating the Dorr Clarifier which forms a part of the equipment.

The cut herewith represents a clarifier 20 feet in diameter and is rated to take the juice of 2,000 tons of cane per day.

A circular tank "A" 20 feet in diameter by 14 feet high, has a conical bottom. "B" is firmly bedded in concrete. The tank is divided into four compartments, C—1, C—2, C—3, C—4. The divisions are made by circular conical plates "D" fastened tightly to the periphery of the tank "A." The slope of the cone towards the center is the same as that of the bottom.

On the upper division plate "D" rests the feed well "E" about 8 feet in diameter by 2 feet 6 inches deep. The feed well "E" is provided with a juice inlet pipe "F" with revolving skimming paddles "G" and a discharge outlet "H" to a launder "I" for conveying skimmings.

In the center of the tank is placed a vertical shaft "J" which revolves once in six minutes. On this shaft are fastened arms "K" which carry scrapers "L" that touch the conical plates "D." The feed well "E" has a central tube "M" reaching into the compartment below it and in a like way from subsequent compartments to the next below.

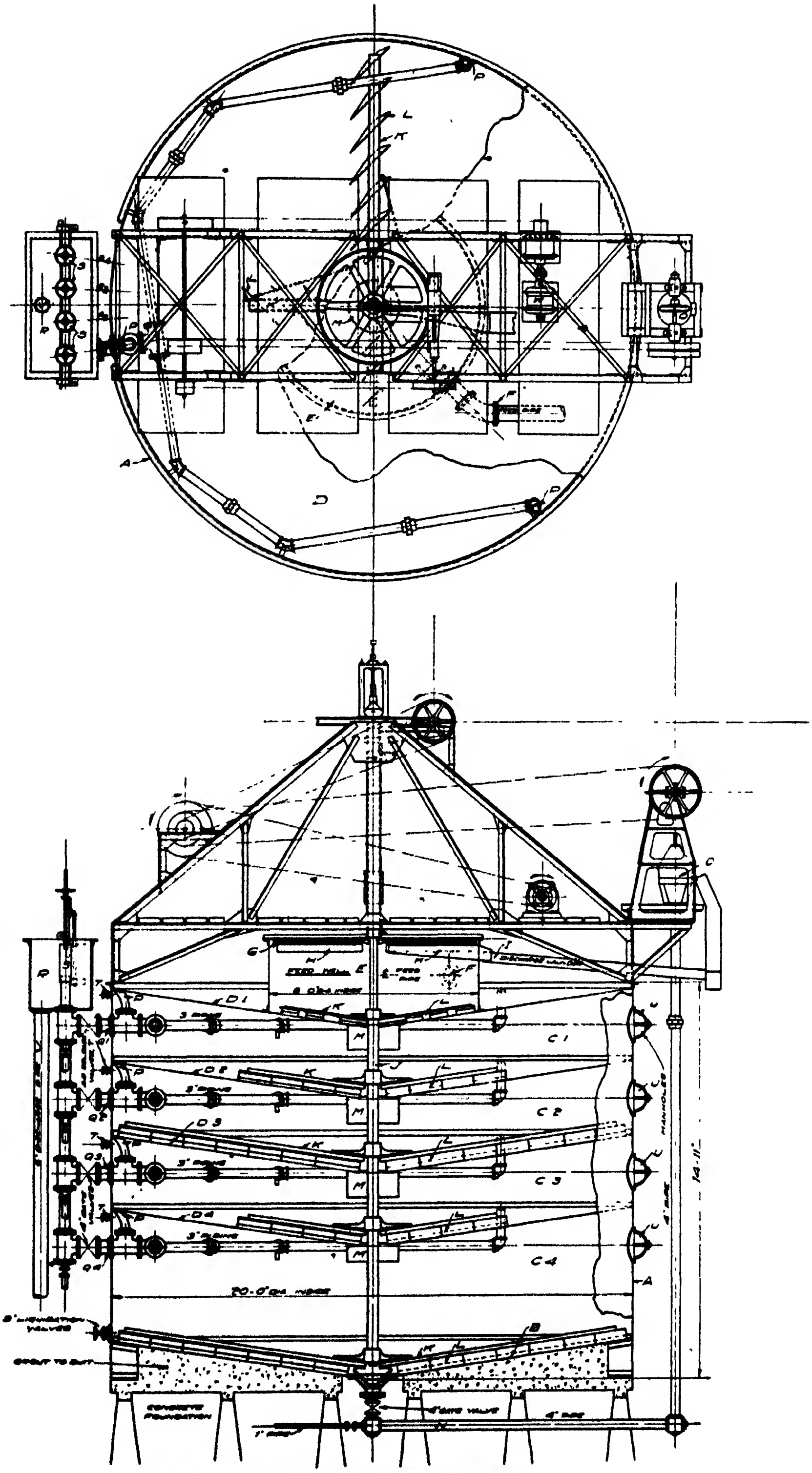
The center of the tank bottom is connected to a 4 inch pipe "N" which conducts by the suction of the pump "O" the mud to the mudpresses. The clear juice is drawn from each compartment at three equally spaced points "P" at the highest part of the compartment near the periphery of the tank.

The clear juice pipes "Q" from each of the compartments are connected separately outside the tank to an overflow box "R." The top edge of this box is level with the feed well overflow. The height of overflow can be regulated separately by screw and handwheel operated sleeves "S" and the rate of flow increased or decreased by this adjustment. Air vents "T" and manholes "U" with covers are provided.

The following contribution was received from Mr. W. L. McCleery, Assistant Sugar Technologist of the H. S. P. A. Experiment Station:

My experience with the Dorr Clarifier, or Dorr Thickner as it is called on the mainland, was in its use in beet sugar work in the Steffens molasses desugarizing process. It was used as a thickner in concentrating the precipitate in hot waste. Approximately 80% of the volume of material fed to the Dorr overflowed as an absolutely clean liquid, and the remaining 20% was a mud drawn off at the bottom which was then filtered on vacuum filters.

The apparatus is simple in construction, and consists of an insulated and closed steel tank, equipped with several steel trays which form settling compartments connected with each other by central openings. There is a very slow moving vertical shaft arranged with arms to sweep the surface of each tray. The shaft revolves once in about seven or eight minutes so that the power required to drive the mechanism is very small. There is



GENERAL ARRANGEMENT OF 'DORR' CLARIFIER
FOUR COMPARTMENT TYPE.

a so called "loading well" attached to the cover, in which skimmers, operated by the central shaft, remove all foam. Our overflow was always equal to the finest filtration when the material was heated correctly to give a good settling rate. The temperature loss was not over 3° Centigrade. It does not require a skilled man to operate the installation. In fact, when once adjusted and with regular running very little attention is required.

It is my opinion that this clarifier would be very satisfactory when operating on cane juices. The floor space occupied is much less than required with the usual form of settling tanks used in these Islands. The time that the material is in process should be much less, and the temperature loss is very small compared with that of intermittant settling. The moving scrapers in the bottoms of the trays should make the apparatus self cleaning, which is an advantage over our present operations. The Dorr installations, however, should be sufficiently large to take care of slow settling juices, as with the present intermittant form of settling, if a small batch of poor settling juice is encountered the tanks containing the poor settling juice can be held out of their turn, if necessary, without slowing down the factory to a very great extent. The Dorr therefore does not have this flexibility that intermittant settlers have.

With good settling juices the Dorr should prove very satisfactory. With poor juices chances will have to be taken on having sufficient settling capacity. It is possible that the latter juices may work better in the Dorr than in the usual settlers, because the Dorr is very well insulated, not only to conserve heat, but to prevent the setting up of convection currents in the juice due to unequal temperatures. There must be a large amount of these convection currents set up in many of our intermittant tanks, due to the small amount of insulation used and lack of covers. This is a great detriment to efficient settling of juices which have a tendency to settle poorly.

In connection with fine juice-screens to remove suspended matter from the clarified juice, Mr. Raymond Elliott, Chemist of the Paauhau Sugar Company, writes:

During the early part of the 1922 crop, the Gartley Bagasse Juice Filters were discarded. It was thought that a revolving screen would do the work just as well and at the same time release two men for field work.

The revolving screen installed was 30 inches in diameter by 54 inches long, having 35.3 square feet screening area. The screen was 50 mesh, brass woven wire. After several days the screen began to crack and tear, due to the expansion and contraction of the heat. After replacing, the same thing happened again and a flat screen was installed. This screen is a 50 mesh Monel metal woven wire, 54 inches wide by 48 inches long, giving 18 square feet screening area, and is backed by an old mill juice screen. The angle measured from the horizontal is 13.5 degrees.

The juice from the clarifiers flows to an iron box, where the front is cut away, so as to distribute the juice evenly over the surface. The screenings are raked off with a soft wooden hoe, into a round flume, connected with running water, which flushes it to the mud tanks. The man who tends the evaporator, also looks after the screen. The flat screen has not given any trouble and is just as good as the day it was put in.

The following tabulation, taken from data supplied by the Crockett refinery, shows the progress made in the attempt to reduce the quantity of suspended solids in the raw sugar:

	1916	1917	1918	1919	1920	1921
Hawaiian Commercial & Sugar Co.........	.060	.033	.041	.051	.035	.024
Maui Agricultural Co.....................	.070	.052	.090	.107	.075	.073
Kahuku Plantation Co...................	.078	.042	.056	.053	.070	.051
Hutchinson Sugar Plantation Co..........	.047	.040	.041	.065	.047	.046
McBryde	.037	.035	.054	.076	.068	.064
Wailuku	.049	.043	.076	.110	.113	.132
Hawaiian Agricultural Co...............	.050	.050	.079	.087	.065	.052
Onomea	.051	.045	.047	.061	.052	.040
Pepeekeo	.040	.043	.031	.058	.046	.036
Honomu	.041	.035	.040	.045	.041	.035
Hawaii Mill	....	.031	.033	.042	.037	.034
Kaiwiki Sugar Co......................	.040	.043	.064	.047	.045	.064
Hamakua Mill Co......................	.094	.061	.147	.117	.119	.098
Laupahoehoe Sugar Co..................	.138	.108	.157	.085	.062	.069
Waiakea Mill Co......................	.075	.056	.086	.070	.053	.036
Union Mill	....	.206	.205	.243	.196	.113
Olaa Sugar Co........................	.113	.097	.097	.105	.074	.086
Oahu Sugar Co........................	.049	.047	.065	.111	.065	.041
Kipahulu	....	.064	.146	.134	.160	....
Pioneer	.059	.044	.038	.064	.055	.048
Koloa	....	.053	.061	.071	.064	.064
Makee	.073	.060	.057	.073	.044	.047
Ewa Plantation Co.....................	.075	.045	.068	.072	.045	.043
Kohala	.061	.058	.056	.060	....	.046
Honokaa	.054	.052	.143	.079	.096	.116
Hawi	.049	.049	.038	.076	.058	.048

ENTRAINMENT.

Quite a few factories are again experimenting with different devices to reduce juice entrainment.

Mr. E. Kopke writes as follows in a recent publication:

Entrainment may be caused (a) by splashing, (b) by finely divided particles of the sugar-containing-mass being carried along with vapors (this is called "vesicular transference") and (c) by "creeping," (a film of juice having been deposited on the sides of the cell or vapor-pipe is induced to creep in direction of the flow of vapors and finally becomes lost in the condenser), or by (d) drain pipe from save-all short circuiting into vapor space of cell instead of into the body of juice in cell or through a U-tube.

Conditions favorable to splashing are long tubes of small diameter, maximum height of liquor to top of upper tube sheet but not over it, and high vacuum in last cell and great temperature difference between vapor of last and second last cell.

Mr. A. Fries, Chemist of Honokaa Sugar Company, reports as follows:

The separators or save-alls used in former years in the vapor pipes of evaporators had as their principal feature the sudden increase in volume, thereby causing a sudden reduction in vapor velocity and bringing about the bursting of the bubbles, which contain vapor and sugar. In connection with this reduction in vapor velocity, baffle plates were used

and so arranged as to cause a reversal of the vapor current and the throwing of the bubbles against the plates, thereby releasing the vapor and allowing the liquid to drop back.

A design of separator extensively used in the islands for some years is a type made of a series of short tubes inserted in three or four sheets. The whole is placed in an enlarged section of the vapor pipe, in which case the vapors generally pass the tubes in a horizontal direction, or into the dome of the evaporator cell, when the vapor traverse the tubes vertically.

The difference between this type of save-all, known as the "Stillman" and the above is that there is no sudden reduction in vapor velocity, as the area of the tubes is only slightly larger than the area of the vapor pipe. Not having this principal feature of the old style save-all may account for the fact that in some instances the Stillman has not been sufficient to stop entrainment in evaporators. In one factory using Lillie Evaporators, the Stillman traps reduced but did not eliminate the loss of sugar through entrainment. It was said, however, that the design, being one of the first in the islands, was faulty. Another factory, using a Stillman of the vertical type, in connection with a standard evaporator, showed considerable entrainment, which was completely stopped after putting in a six-foot belt and installing baffle plates inside the vapor space of the last cell. During the 1921 crop there was quite a loss of sugar through entrainment of the Honokaa evaporator. To remedy this the old baffle plates were removed and replaced during the off season by a Stillman trap, placed inside the last cell above the top flange. The entrainment from the start was much greater than in the previous year, amounting at times to a loss of 1000 to 1500 pounds of sugar per 24 hours. As there was nothing wrong with the evaporator or the method of operating it, the fault could only be with the newly installed Stillman. This was confirmed when it was found that the difference in vacuum above and below the trap was three-fourths of an inch.

To stop further loss as quickly as possible wooden baffle plates, as a temporary arrangement, were installed in the early part of the season and accomplishing what was desired, were kept in use throughout the rest of the crop. There is nothing new about the arrangement of these baffles, Mr. Orth introduced it with good success at Koloa and later the Makaweli Factory installed the same system, thereby completely stopping all entrainment. After placing the wooden baffles in the Honokaa evaporator the entrainment loss was reduced to a reasonable figure, when running at the rate of forty tons of cane per hour, while at a lower rate of evaporation no sugar could be found in the condenser water. It is expected that after replacing the wood by iron that the entrainment will be eliminated under any condition of evaporation. It may reasonably be concluded from the above that a Stillman trap is not in every instance capable of stopping entrainment, in fact it may increase it as the experience here has shown.

The following data refer to the detail of design:

Diameter of cell	8' 7"
Top tube plate to top flange	8' 4"
Diameter vapor pipe	26"
Stillman trap, number of tubes in 1 plate	160
Diameter of each tube	2¼"
Total area of tubes	635 sq. in.
Area of vapor pipe	520 sq. in.

Mr. McAllep in his report after the yearly inspection of the factory comments as follows:

"Previous to this season the old baffle plates were removed from the last cell of the evaporator and a Stillman trap installed. Frequent tests indicated that the entrainment was increased rather than reduced. Early in the season a wooden baffle was installed under this trap reducing the entrainment to a small amount, though, according to these tests, not entirely stopping it. Some three weeks prior to my visit the entrainment started to increase. On Sunday the wooden baffles which had shrunk at some places

were repaired and on Monday a test by me failed to show any loss through entrainment. On this day, however, the evaporator was operated at a somewhat lower capacity than usual. According to calculations made from the laboratory figures, 28.5 tons of water were evaporated per hour against an average for the preceding week of 31.4. Some entrainment might still take place at the higher rate of evaporation even though this test was negative.

"I was very much interested in the failure of the Stillman trap to stop entrainment as in all but two or three cases that have come under his notice, this style of trap has been very efficient. A possible explanation lies in the throttling effect of this installation. According to figures given me the tubes have an area of 4.4 sq. ft. Mercury gauges on the last body below and above this trap indicated respectively, 24.5″ and 25.25″ vacuum, a difference of ¾″. As this factory is 460 feet above sea level, a correction of approximately half an inch must be added to these figures, making them 25″ and 25.75″. With an evaporation of 30 tons of water per hour, some 8.4 tons would be evaporated in the last body. Under these conditions the vapor would enter this trap with a velocity of slightly over 150 feet per second and leave it at 180 feet. The temperature of saturated steam at these two points would be 133 and 127 degrees. It appears probable that such instantaneous decrease in the boiling point would cause drops of juice carried along with the vapor to boil with almost explosive force, and that the resulting spray would be carried through the trap with the current of vapor."

Others seem to have had about similar experiences with the Stillman trap. Mr. Elliott tried to determine the exact quantity sugar loss and gives the following description of his test:

September 18th to 23rd inclusive, a test was run on the entrainment indicator of the fourth effect to ascertain the amount of syrup entrained. The syrup was weighed, composited and analyzed every three hours. The evaporators were working under normal conditions, mill working day shift only.

The data are as follows:

ENTRAINMENT FROM FOURTH CELL INDICATOR.

Date	Time in hrs.	Net lbs.	Analyses			Vacuum				
						1st Cell	2nd Cell	3rd Cell	4th Cell	Cdnser
			Brix.	% Pol'n.	Purity	Vacuum	Vacuum	Vacuum	Vacuum	Vacuum
9/18/22	12	211	10.09	8.36	82.85	1.70	7.08	13.75	24.3	26.42
9/19/22	12	220	11.15	9.25	82.96	1.70	7.50	14.33	25.5	27.00
9/20/22	12	208	11.00	9.21	83.73	1.00	6.84	13.83	25.6	27.00
9/21/22	12	199	12.39	10.38	83.78	.67	7.67	14.42	25.8	27.00
9/22/22	12	205	16.33	13.75	84.20	1.67	8.33	14.30	26.0	27.10
9/23/22	8	131	13.50	11.12	82.37	0	5.50	12.90	25.8	26.90
True Av.	68	1174	12.31	10.27	83.43	1.16	7.15	13.92	25.50	26.90

Syrup brix and purity, 60.99 and 85.2 respectively, for the week ending September 23, 1922.

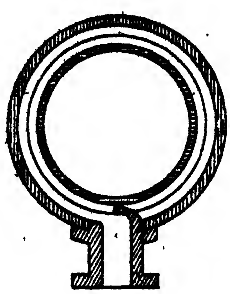
The fourth effect is a Catton Neill Evaporator, 7 feet in diameter containing 910 tubes, 1⅞ inches I. S. diameter by 54 inches long, giving 2010 square feet H. S. Height from top of tubes to center of vapor pipe, 9 feet 6 inches. The two vapor pipes to the central condenser are 24 inches diameter. Each vapor pipe is fitted with two screens, one 5x5 mesh, the other 3x3 mesh, to retard any particles of syrup going over. These screens are placed 5 feet apart, the smaller mesh, placed nearest the condenser.

Using the above figures, the calculated velocity of the vapor to the condenser is 112.06 feet per second.

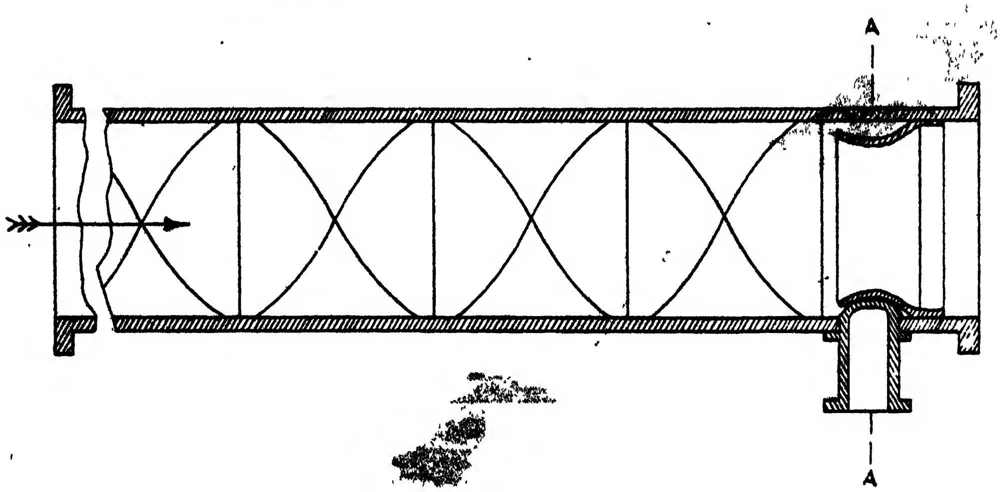
$$\frac{1174 \times .1027}{96.5} = 124.94$$ lbs. 96.50 deg. sugar that is returned to the fourth cell for week, or 1.84 pounds per hour.

A plan and description of the entrainment indicator is given on page 327 of the *Hawaiian Planters' Record*, December, 1921.

Mr. A. Barker, Engineer at Halawa Plantation, presents the following description of an entrainment catcher of his own design:



SECTION AT A.A.



During the latter part of this season, a new type of entrainment trap was fitted to the last effect at Halawa, with very noticeable effect and success. From the time we commenced grinding, it was evident, by mere observation of the waterlegs of the third effect and small pan, that heavy entrainment was taking place. I suggested putting in an entrainment catcher of my own design and it was agreed to try one. This was made at the plantation and fitted on May 24, 1922. It has been in operation ever since.

This entrainment catcher is fitted in the regular vapor pipe from the third effect and no new castings are required, in fact everything can, if required, be made at the mill. It consists of two principal parts, a true screw and a Venturi tube. Its action is based on the fact that the vapors passing to the condenser are travelling at a very high speed, in this case, for the season, it averages 14,414 feet per minute.

A true screw of 4 feet pitch was inserted for a length of 8 feet in the vapor pipe, giving a centrifugal force 4.8 times greater than a 30 inch machine at 1200 r. p. m. By this means, all liquids in suspension are thrown out to the walls of the pipe and no liquid or

particles of liquid can possibly reach the end of the screw without reaching the walls, and splashing on these walls is, of course, negligible.

Now, of course, by altering the pitch of the screw, the centrifugal force may be increased to any desired extent and consequently, for any known speed and diameter of pipe, the requisite pitch can be determined easily when the length of screw is known, as this affects the important factor, the time factor.

At the end of the screw is a Venturi tube. All the liquids on the walls of the pipe either return along the vapor pipe or are caught between the Venturi tube and the walls and returned by the pipe to the third effect.

In this case, with 16 inch pipe, the Venturi tube was restricted to 13.5 inches and yet no loss of vacuum was observable. Sugar bubbles were no longer seen at the foot of the water leg and alpha napthol always showed a negative test to the condenser water.

In August, Mr. McCleery visited the mill and sampled the water from the water leg and the flume, which water was being used as condenser water. His figures show that we were losing about 8 pounds of sugar per day. A series of tests were then made and the average of thesq was 17.44 pounds sugar lost per day or 1.608 tons for a season of 185 days, giving a saving of 128.442 tons pol. for season.

In designing a catcher of this type, the speed of the vapor is not only made use of but is increased if necessary to give the necessary centrifugal force that enables the particles of liquid to reach the walls of the pipe in the time allowed. This factor of time is the principal one to be considered, and, in conjunction with the rate of boiling, vacuum carried, length of pipe available and diameter of pipe, determines the pitch of screw and size of Venturi tube; and the fact that this catcher as fitted saved over 128 tons pol. during the season is an indication of what can be done with one of efficient design, though the labor employed in manufacture was of the regular unskilled mill type.

Mr. Charles P. Bento, Sugar Boiler of Wailuku Sugar Company, sent us a sketch with the following description:

In experimenting for the best way of working the baffle plates of save-all we have come to the conclusion that by putting three baffle plates in the front and two in the back with ¼ inch mesh screen in between it would work the best.

In testing the save-all we have two 3-inch pipes connected from save-all to two small tanks on the evaporator floor, one three-quarter inch pipe connected to a small surface condensor on the vapor pipe back of the save-all, leading down to a small tank on the evaporator floor, and from that surface condensor we would detect the entrainment going over. At the end of the season we noticed that the two inch tubes on the baffle plates were corroded with sugar and hard to clean.

The following letter was received from Mr. Searby, Assistant Manager of American Factors, Ltd., giving a tabulation of the various additions and improvements of the factories under its control:

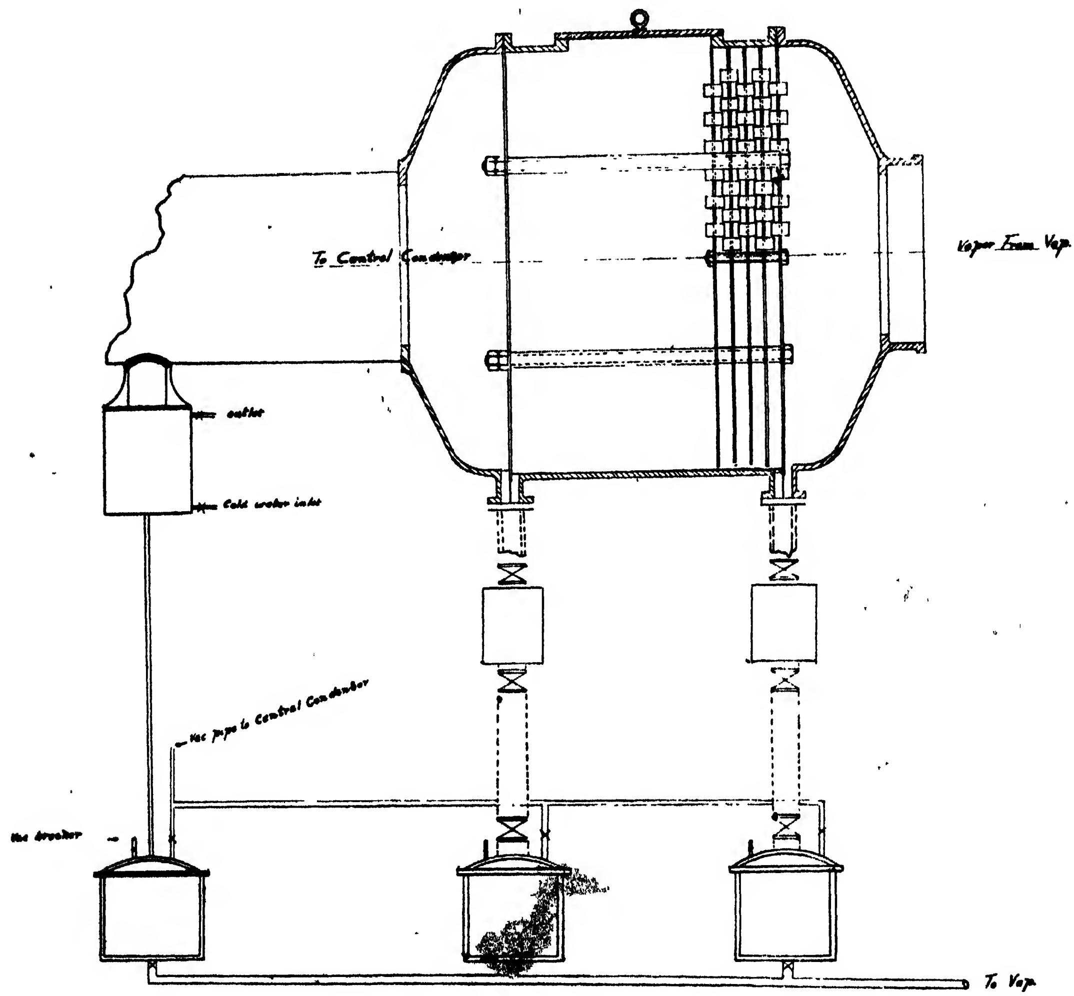
Lihue: The addition of two cells of 4000 square feet heating surface each to the existing quadruple effect of 8800 square feet, and the rearrangement of connections so that the old first and second cells and third and fourth cells act as first and second effects respectively of an enlarged quadruple effect, has practically doubled the evaporator capacity of this factory.

This has permitted an increase in the grinding rate of 9% and in the dilution of about 40% while at the evaporator the brix of the syrup has been increased from 56 to over 60.

The advantages of this being able to apply a dilution commensurate with milling equipment and tonnage ground, as well as to evaporate to a satisfactory density, need not be commented upon here. The advantages of an increased grinding rate have been recognized in the last two years particularly where the efficiency of the loaders has been

such that more cars have been needed to handle the same amount of cane and where there has been an actual shortage of cars.

Bringing of evaporators to the above standard has permitted cutting out two heaters which were previously necessary to bring clarified juices to the temperature of boiling in the first cell, this being necessary to enable the first cell, and consequently the entire set, to work at its maximum capacity. The direct result has been a reduction in cleaning expense.



The addition of eight 30, inch centrifugals and four crystallizers has brought the capacity at both of these stations to slightly above standard, and the molasses purity of 36.6 for the season has demonstrated the value of ample capacity for low grade work.

Makee: Among the improvements at this factory may be mentioned the installation of four 7'x20' H. R. T. boilers of 315 B. H. P. each to replace four 6'6"x18" H. R. T. lap seam boilers of 171 B. H. P. each, two 900 square feet H. S. juice heaters, one 1800 cubic feet and 1800 square feet H. S. Calandria vacuum pan, and the installation of two motors, a 100 H. P. motor to drive 13-40" B. D. Centrifugals, and a 30 H. P. motor to drive the crystallizers and sugar handling equipment, to replace a 16"x36" Corliss Engine. The power to drive these motors is obtained from an hydro-electric plant above the Mimino Reservoir where an obsolete wheel having six runners each of a different diameter for maintaining different voltage or frequencies has been replaced by an up-to-date Pelton wheel with Woodward oil governor actuating a stream deflector.

Olaa: The new equipment installed at this factory consists of—

7 7'x20" H. R. T. Boilers.

1 1800 cu. ft. 1800 sq. ft. H. S. Calandria Vacuum Pan.

1 12"x27"x16" Ingersoll-Rand Dry Vacuum Pump.

1 10"x16"x10"x14" Air Compressor, and equipment for lifting a million gallon of water per day from two deep wells by means of air compression.

The first item of seven boilers all built in conformity with the A. S. M. E. Boiler Code, was to replace an equal number of the same size, but having lap riveted seams, and on which the working pressure had been reduced to such a point that their retention in service was inimical to fuel economy.

The 12"x27"x16" dry vacuum pump was installed to replace three water sealed, direct acting vacuum pumps on the pans and two smaller rotary vacuum pumps on the evaporators, one of the latter an Alberger, being retained to bring up the vacuum in the pans and evaporator before cutting in on the main pump.

The 1800 cubic feet Calandria Vacuum Pan is expected to assist in the steam balance at this factory, there being now four pans and opportunity to arrange working so there will be no extreme peaks in consumption. The substitution of copper for charcoal iron tubes in the three old pans is expected to improve the work in these pans by permitting faster boiling.

The air lift equipment has been installed to replace two deep well plunger pumps which have given continual trouble, due mainly to sand infiltration. The present wells and pumps having no movable parts are entirely free from this objection, and yield slightly over a million gallons of water per day against a head of 205' when supplied with 600 cubic feet of free air per minute. The advantage of having an auxiliary supply of fresh water for domestic use and condensing purposes when the natural run-off fails, needs no argument here.

Kekaha: During the present off-season this factory is installing 2 18-ton Calandria Vacuum Pans, each having a ratio of capacity to heating surface of one to one; sixteen 800 cubic feet crystallizers to replace an equal capacity in miscellaneous small tanks and coolers, 2 270 H. P. H. R. T. Boilers to replace two smaller size boilers which have been condemned, and four 40" American Tool and Machine Belt Driven Centrifugals. In addition a 700 square foot heater is being rearranged and fitted with baffles for a more efficient circulation of the steam and removal of incondensable gases.

Your committee wishes to thank those who have been kind enough to give their cooperation, and hope that these contributions may furnish material for a thorough discussion of the many unsolved problems we still have with us in the manufacture of sugar.

The Influence of Fertilizers Upon the Productivity of the Soil.*

It was found, by growing barley under forcing-house conditions, on nine different types of soil consisting for the greater part of loams, the vegetative growth was influenced very little by the application of either litter or leaf-mould. During the first year's experiments, well-composted farm manure did not produce additional growth, although the results obtained with it the second year were satisfactory, but the plants to which commercial fertilizers were applied grew much more than those receiving stable manure, the quantities of nitrogen, phosphoric acid and potash being the same in the two cases. Slaked lime applied with farn manure had a very irregular effect according to the different types of soil; in short, nitrogen appeared to be the sole fertilizing substance having a marked influence upon barley.

To confirm these results, two soils were selected, one highly productive, and the other less fertile, and barley again planted. It was found that, under forcing-house conditions, the soils appeared to supply sufficient quantities of phosphorus and potassium for luxuriant vegetation.

The application to the soil of soluble compounds of nitrogen, phosphorus and potassium, materially increased the proportion of water solubles in the soil; these were used by the plants, and their amount was thus rapidly reduced before the barley had attained considerable growth. In the latter stages of its development, the quantity of the water-solubles remained constant and was much the same (with the exception of the phosphorus) as that present in the soil receiving no fertilizer.

To sum up; it would seem that from the practical standpoint, the above data show the importance of the solubility of the three essential ingredients of fertilizers, especially in the production of quickly-growing crops. Plants accumulate a large proportion of the required nitrogen and ash ingredients during the early stages of growth, for which reason, in the case of forcing-house culture, vegetable-gardening, and of such crops as cabbages, potatoes and wheat, an adequate supply of immediately available food appears to be indispensable in order to obtain good results.

*From the International Review of the Science and Practice of Agriculture, Vol. XII, No. 10; abridged from Bulletin 473 of the N. Y. Agric. Exp. Sta., by W. H. Jordan.

Some Notes On Rubber Estates of the Future.*

By VICTOR RIS.

1. THE INFLUENCE OF SELECTION OF PLANTING MATERIAL ON THE YIELD OF RUBBER ESTATES.

Until very recently, in fact, almost until the extensive opening up of rubber lands was discontinued in consequence of the rapidly decreasing price, all rubber estates in the East were planted up with more or less unselected seed. No selection on a clear scientific basis had been adopted anywhere, that is to say, nowhere to any appreciable extent.

The result of planting up such large areas with unselected material is now clearly to be seen everywhere and the following figures illustrate what may be considered to hold good for the majority of estates in the East when their full planted-up acreage is considered.

It may be said that 75% of the planted trees yield 40% of the crop and 25% of the planted trees yield the balance of 60%. These trees are hereafter referred to as Class A and Class B trees respectively.

Of the total number of planted trees on an estate 10% may be said to yield 25% of the crop whilst 1% of the total planted trees yield 5% of the crop. Such trees are hereafter referred to as Class C and Class D trees respectively.

Under "Class A" are included many trees which yield no latex or practically none. Under "Class D" are included trees whose records show they yield year after year between 55 and 60 pounds.

On the basis of these figures we can deduce that an average estate yielding at present 400 pounds per acre per annum could be expected to yield if planted:

With trees	described as	class "B"	960 lbs.	per annum
do	do	class "C"	1000	do
do	do	class "D"	2000	do

The figures further clearly prove what has been already stated above, *i. e.* that not only has unselected planting material been used for planting up estates, but that, taken on the average, poor planting material has been used and that it is most important that for future plantings the planting material should be most carefully selected on scientific lines. In the Dutch East Indies this urgent need has been recognized for a good many years and the highly trained staffs of botanists attached to the experimental stations, and I may here especially mention the Research Stations of the Avros, have been extensively engaged on work connected with the Hevea selection problem. The results of their research work so far obtained show:

(a) That the greatest success is attained in grafting or budding parts of selected high yielders on to the young root system of ordinary trees, thereby solving the problem of multiplication of high yielders in a short space of time.

* From the *Archief voor de Rubbercultuur*, Vol. VI, No. 6, 1922. Translated by the Agricultural Bulletin of the Federated Malay States.

The stems developed from such buddings show all the valuable characteristics of the mother tree. Structure of bark, number of latex carrying vessels, etc., in the offspring stem are equal to those in the mother tree. There is therefore every reason to believe that trees so grown will equal, or at any rate approximate, the yield of the mother trees.

In this connection it is interesting to note, as a further proof that the characteristics of the mother tree will be found in the tree grown from buddings, that the offsprings of yellow latex yielding mother trees yield also yellow latex whilst offsprings of white latex yielders yield white latex. As a matter of fact, one can go so far as to say that if an "eye" of a yellow latex yielder is grafted on to a white latex yielding stem, a tapping cut made at a later date across the grafting point yields in the upper part yellow latex and in the lower portion white latex. This is mentioned, of course, merely as a side light on the possibilities of grafting.

Grafting has passed out of the experimental stage and it can be adopted with the best results for any new rubber clearings. It is a fact that some hundred thousand graftings already have been carried out with complete success and grafting material from highly selected trees is beginning to form an "article of commerce." First class material now is being very eagerly sought for in many quarters. The Avros Research Station alone supplied to its members in 1921 about 6,000 meters of branch of selected trees. One meter carries about 10 sleeping eyes suitable for budding.

(b) The slower process of multiplication of high yielders, *i. e.* the process of generative selection, is also being very carefully gone into and satisfactory results have already been obtained.

After extensive and often pretty costly experiments it has been possible to obtain self pollination on some selected high yielders. In this way it becomes possible to arrive eventually at the isolation of biologically speaking "pure lines," the selection which is considered to be the ideal one. This selection naturally will take time before full results are obtained, because "pure lines" can be determined only as such after several generations have proved to show constant characteristics, *i. e.* proved that the characteristics are hereditary. Moreover even if full results are eventually obtained such "pure line" selection and production of "pure line" seed will very probably never yield sufficient seed for planting up large areas.

The limited number of high class pure line seeds will in all probability mostly be used for growing trees to be used for budding material. Budding as mentioned under (a) will therefore remain most probably the principal method of multiplication of high yielders in a short space of time.

2. The Influence of the Selection of Soil on the Yield of Rubber Estates.

Until quite recently, it was taken for granted in the rubber world that *Hevea Brasiliensis* would grow a paying crop almost anywhere in the tropics. That Hevea can grow anywhere, or at least keep alive anywhere, is proved to be about correct, but the idea that Hevea would yield a paying crop anywhere has

been proved to be a fatal mistake. Such mistakes have been made in every rubber planting country in the East; any soil from bare sand flats, peat land to abrupt and rocky hill sides, all classes of soil have been planted up.

The range available for comparison, so far as yield per planted acre goes, is therefore a very wide one and instances of the extent to which the quality of the soil influences the yield per acre are not far to find. They are at hand in every rubber producing country. I intend to deal hereafter especially with conditions prevailing in the East Coast of Sumatra, but all that is to be said can be taken as holding good, ***mutatis mutandis,*** in other eastern rubber producing countries.

The bulk of the estates are, as already stated, planted up with unselected seeds originating all from the same sources and the estates, therefore, from this point of view, can be taken as being built up on parallel lines. The seed factor can thus be eliminated when the yields of different soils are compared; so also can climatic conditions which are excellent from seacoast to the foot of the hills, from south to north.

But the yield per acre varies from 250 pounds per acre to 600 pounds per acre in specially good fields, although considerably higher figures are recorded. It is now, I think, quite clear that such variations, a full 140% in yield, form the strongest indication, in fact the clearest possible proof, that the quality of the soil is a prominent factor determining (all other conditions being equal) the yield of the rubber tree.

Eliminating about 80,000 acres planted on East Coast yielding under 300 pounds per acre, the balance can be taken as yielding an average 400 pounds per acre per year. Now keeping in view that there are large fields capable of yielding 600 pounds (and over) one is forced to conclude that proper selection of soil influences the yield by an increase of 50%. Taking extreme figures in this connection, 250 pounds and 600 pounds, the influence would be by 140%.

3. The Combined Influence of Seed Selection and Soil Selection on the Yield of Rubber Estates.

Under heading (1) I have said that:

An acre planted with	class "B" trees	would yield	960 lbs.
do	class "C"	do	1000 lbs.
do	class "D"	do	2000 lbs.
On average soil yielding from unselected seeds			300 lbs.

Under heading (2) I explained that by soil selection the yield can be improved by 50% as compared with the yield of existing average estates. Therefore:

One acre class "B" trees	planted on selected land	can be expected	to yield	1440 lbs.
One acre class "C"	do	do	do	1500 lbs.
One acre class "D"	do	do	do	3000 lbs.

In the light of yields as now obtained on average rubber estates these figures seem extraordinary, but in my opinion one must look at same as possible figures, certainly so, as far as the intrinsic yielding capacity of selected fields is con-

cerned. The first two mentioned should be obtainable under reasonably careful selection of both factors, seed and soil, whilst the third should be obtainable under exceptionally favorable circumstances and is therefore more of theoretical interest only. Still, personally, I should not venture to estimate for such yields in respect of any larger rubber areas to be opened up in future notwithstanding that I am fully convinced that rubber estates can be laid out and show an intrinsic yielding capacity as stated for class "B" and class "C" trees.

But intrinsic yielding capacity and actually obtainable yields are two different matters. A number of factors such as, for instance, the necessity to rest a number of trees from time to time, the influence of the tapping system and tapping force on the yield, are factors which in practice must tend to keep the actual yield well below the maximum the trees are theoretically able to give.

As regards "resting" nothing at this juncture can be said for certain, but from past experience one can deduce the trees benefit greatly by being rested from time to time for shorter or longer periods.

As regards "tapping system" the final word certainly has not yet been said, but in all probability any new system for extracting latex from the trees will always be a system by which not the last drop of latex will or can be extracted and by which the cambium will not be overirritated. Past experience with drastic systems, the cause of Brown Bast and all the misery connected with such, have served as a good lesson.

So far as the influence of the factor "tapping force" goes, every one knows that in the way the tapping force must be used at present, little chance is given the individual tree to yield its best. Improvements as compared with present day methods will certainly be effected in the future but the actual results obtained by any large force, even the best, will always remain below estimated possible results. No large force will ever consist of ideal tappers only; one will always have to be content with average skill.

How these factors, and perhaps many others, will affect the actual yield if such is compared with the intrinsic yielding capacity, is difficult to ascertain at this juncture. A number of those who apparently forget to take the adverse factors into their calculations estimate future yields to reach 1500, 2000 and more pounds per acre, and others who are more conversant with the practical daily working of estates, do not hesitate to estimate for at least 1200 pounds. In my opinion the latter will be nearer reality than the former.

For the purpose of the following calculation I take a yield of 1000 pounds per acre per annum and in doing so, I am sure I am on the safe side. (Selection influence the yield of sugar cane* and cinchona by almost tripling the output as compared with former unselected cultivations.)

4. Calculation of Cost per Pound of Rubber for Estates in Full Bearing of 2,000 Acres Yielding 2,000,000 Pounds per Annum.

It can now be safely stated that estates producing 400 pounds per acre under no restriction scheme can place their rubber on the London market at an "all in cost" of 40 cents or say 8d per pound. Of that sum 26 cents represents "Estates Cost" and 14 cents the cost from f.o.b. to "Sold London."

* This evidently refers to the selection of better seedling varieties and not to bud selection work.—*The Record.*

The "all in cost" per pound for producers of 1000 pounds per acre would fall to about 25 cents or approximately 5d. per pound "all in."

The annual net returns per acre from estates yielding 400 pounds and 1000 pounds respectively therefore compare as follows:

Selling price per lb.	Net return per acre yielding 400 lbs.		Net return per acre yielding 1,000 lbs.	
5 d.	loss	£ 5.—.—		£ —.—.—
6 d.	do.	3. 6. 8	profit	4. 3. 4
7 d.	do.	1.13. 4	do.	8. 6. 8
8 d.		—.—.—	do	12.10. 0
9 d.	profit	1.13. 4	do.	16.13. 4
10 d.	do.	3. 6. 8	do.	20.16. 8
11 d.	do.	5. 0. 0	do.	25.—.—
12 d.	do.	6.13. 4	do.	29. 3. 4

The uncertain factors of government income taxes are of course left out of account.

The actual capital cost per acre of the existing 400 pounds yielders can probably be taken as falling between £50 and £60, whilst the cost of the 1000 pounds yielders to be opened up in future may be taken as lying between £70 and £80.

Considering the possibilities and merits of stringent selection of planting material and soil to be planted up, one is perhaps doing well to bear in mind the excellent results obtained in the Dutch East Indies during the latter half of the last century in the cultivation of the sugar cane, cinchona and tobacco, and to remember that no other Eastern Tropical colonies can compete successfully with the Dutch East Indies on the world's market in these lines.

Medan, January, 1922.

Studies in Indian Cane No. 4.*

(Concluded from last issue.)

By C. A. Barber.

Literature Concerning the Effect of Spacing on Tillering and on Other Crop Characters.

The most obvious way of regulating the number of canes produced at harvest time is by varying the number of sets planted per acre. Spacing experiments have been conducted wherever the sugar cane has been cultivated, for the seed material, in many cases obtained by cutting up canes perfectly fitted for passing through the mill, costs a good deal and figures largely in the balance sheet. In

* From Memoirs of the Department of Agriculture in India, Botanical Series, Vol. X.

some countries only tops are planted, namely, the upper, immature parts of the plant where there is no sugar, and the canes harvested produce these in sufficient numbers to plant up the new fields; but, in other places, tops are not available, as they form a valuable cattle food, and in India, for instance, are often the perquisite of the men from whom the cattle are hired for crushing the canes. We have already referred to the curious fact that, even in India, there are varieties which cannot be successfully reproduced from the matured cane sets, but such exceptions are comparatively rare. When the Samalkota farm was started in the Godavari District, it was the local practice to plant 25,000 to 30,000 sets per acre, and the cultivators were quite content to put aside Rs. 30 to Rs. 40 for the purchase of seed per acre. A series of experiments was therefore initiated with the number of sets planted, varying from 4000 to 30,000 per acre. The number of canes produced at harvest were counted and the amount of *jaggery* produced was estimated. These figures are now unfortunately lost, but the general conclusion arrived at was that, with proper treatment, each piece of land would produce the same weight of canes within comparatively wide limits, but that, when thick canes were sown at the rate of 12,000 sets to the acre, the maximum yield might be counted on, and that closer planting merely led to unnecessary expense in the purchase of sets. A similar series of experiments was made with *Reora of Benares* in Partabgarh in North India,[1] varying numbers of sets being planted per acre and the resulting yield of *gur* compared. Here too, 12,000 sets per acre were found to produce the most satisfactory results, and the larger number of sets usually planted by the ryots did not give any increased yield. At first it strikes one as rather curious that thick and thin varieties, with their greatly differing tillering power, would require the same amount of space for their best development. But it must be remembered that the number of buds per sets was considerably greater in *Reora* because of its short-jointed character. The number of sets planted per acre on different farms in North India appears, however, to differ very considerably and it is not known whether these numbers are the result of series of spacing experiments, such as those made at Samalkota and Partabgarh, or are merely an adoption of the local ryots' practice until such experiments can be conducted.

Stubbs[2] quotes a certain Mr. Skeete, who speaks of sets planted six feet apart, with the result that often 50-100 canes were reaped from one hole. We have been unable to verify this reference or to discover what country is spoken of, but it appears to be not at all unlikely, for Prinsen Geerligs[3] states, of San Domingo in the West Indies, that the canes are occasionally planted nine feet apart each way, which would mean only 538 sets to the acre, and presumably the tillering in such cases would be great enough to make up the requisite number of canes at harvest time. It is the custom at the Cane-breeding Station to give the thick canes more room than the thin, in spite of their smaller tillering power, and this appears to be the general rule in India where these two types of canes are planted on the same farm. There is, however, a much more liberal application of manure in the former case, for the thin canes are found to be unable to

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[1] Clarke, Annett and Hussain, etc. Experiments on the cultivation of sugar cane at the Partabgarh Experimental Station, 1910-11. *Bull. No. 27, Agr. Res. Inst., Pusa,* 1911.

[2] *Ibid,* p. 95.

[3] Geerligs, H. C. Prinsen. *The World's Cane Sugar Industry, Past and Present,* p. 193, 1912.

assimilate such heavy dressings and, at the same time, to mature properly at harvest time. The object aimed at in each case is to obtain a full stand, with as great a weight of canes as possible, without unnecessary expenditure in costly seed material. The development of the cane clump is influenced by warmth, moisture, soil, and no strict rule can be laid down as to the most suitable spacing, and hence the importance of the very numerous experiments which have been made.

Several workers have dealt fairly fully with the relation between spacing and the number of canes reaped, and it will be necessary to consider their papers somewhat in detail. As other matters besides the influence on tillering are also included in them, it will be convenient to treat these papers as a whole, and append a summary of conclusions at the end under the several headings.

Stubbs, in 1892-93, conducted experiments with the local Louisiana canes by planting the sets at distances of 6", 12" and 18" in rows five feet apart. The plants were first reared in a nursery and, as each was planted in its plot, care was taken that it was the result of the growth of only one bud. His results are given in the following table:—

Spacing	Number Planted in March	Shoots in June	Shoots in October (Harvest)	Average Weight of Each Cane	Tonnage
6"	17,600	72,325	39,050	2.17 lb.	42.55
12"	8,800	51,188	32,964	2.49 lb.	41.60
18"	5,860	37,230	29,070	2.60 lb.	37.24

These figures show a greater number of shoots arising in the more closely planted rows, but a gradual diminution of the differences in these numbers as growth proceeded. Inversely, there was an increasing weight of individual canes with greater spacing, but the tonnage was greater in the closely planted plots. Stubbs concluded that tillering depends on room available, and that there is practically no limit to it, provided the space given is sufficiently ample. In 1894-95 he carried out the same experiment with much greater care, studying each plant throughout its growth. Five plants of each of the two varieties, the *Striped* and the *Purple*, were used in each experiment, so that altogether there were thirty plants. A book was kept of births and death by the chemists in charge, who also labelled each shoot as it appeared. At harvest each clump was dug up and the labels examined, the parent stalks were marked and their relation to their branches; each cane was separately weighed and analyzed. It is impossible to conceive of a more strictly scientific method, and the results are well worth study, especially as the conclusions arrived at are at variance in some respects with those of others to be referred to below. More shoots started with the wider spacing, but the ultimate number at harvest was practically the same.

The next pieces of work on the effect of spacing on the number of canes produced are in 1910, when independent experiments were conducted by Kilian and Muller von Czernicki in Java. Kilian's experiments[4] were made with *J. 247*, a late but good tillering variety, on dry loam, "strugge"[5] loam and heavy black clay. It is unfortunate that the control plot of the latter was destroyed by fire; this class of soil, namely heavy clay, is apparently less suited to *J. 247*, and the results recorded of the single experiment show that some unmentioned factor has intervened. This plot we have accordingly left out in the discussion, and confined our attention to the four others, on loam of varying fertility. Kilian planted his sets in rows 3½', 4', and 5' apart, and a summary of his results is given in the appended table, averaging the duplicate plots.

SPACING OF ROWS		No. of Canes Reaped per Bouw	Weight of Canes per Bouw in Pikuls	Weight of Sugar Obtained per Bouw in Pikuls	Sucrose per Cent in the Juice
Dry Loam	3½'	65,089	2,070	197	13.76
	4'	62,771	2,056	201	14.06
	5'	59,163	1,978	199	14.33
"Strugge" loam	3½'	55,135	2,092	210	14.40
	4'	54,175	2,023	206	14.58
	5'	50,388	1,946	201	14.81
Heavy Black Clay (No Control)	3½'	40,907	1,633	162	14.23
	4'	48,277	1,745	181	14.60
	5'	40,038	1,536	158	14.75

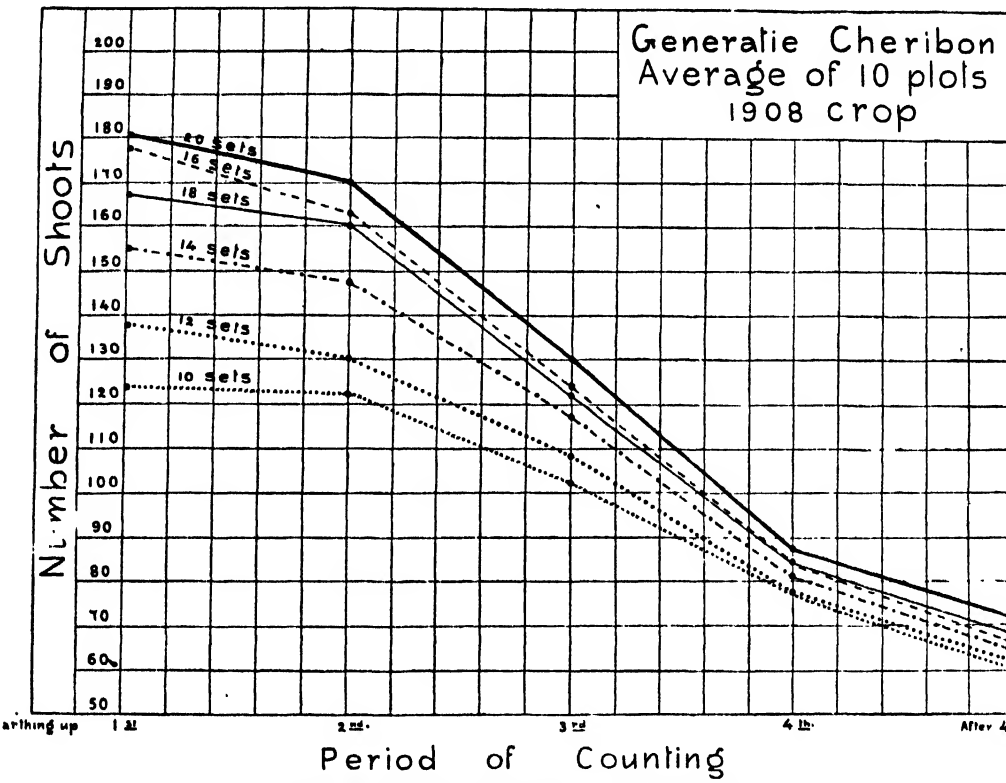
From this table it is seen that the number of canes harvested decreases regularly with the increased width of the rows; the total weight of cane varies in the same sense within narrower limits, suggesting that, with wider spacing, the canes are on the average heavier. The quantity of sugar obtained varies irregularly, the advantage in one case being on the side of closer planting. The sucrose in the juice, however, is interesting, in that there is a uniform rise as the rows are wider apart, and in this respect the aberrant third experiment falls into line, suggesting again that the thicker canes have richer juice. No reference seems to be made by Kilian to this rise in sucrose with wider spacing, but it agrees with the generalization of Kobus and Van der Stok that, in the same plot, the thicker canes have richer juice.[6] Kilian is perfectly justified in drawing the conclusion that the results do not point to any advantage in altering the four-foot rows which appear to be most usual in Java.

[4] Ibid.

[5] We have been unable to translate this word, but imagine that this loam is less fertile.

[6] J. E. Van der Stok, in Fruwirth's *Die Zuchtung der Landwirth-schaftlichen Kulturpflanzen, Zuckerrohr.*

Muller von Czernicki's[7] experiments were on a much larger scale, and extended over several years. His work is the most important contribution which we have met with on the effect of spacing on tillering and the number of canes reaped, and deserves careful study. He had noted great variation in the spacing on different estates, without being able to find any reasoned justification for the local practices. For himself, on his Poerwodadi estates, it was a matter of considerable importance how many sets were used per acre, as much of the seed

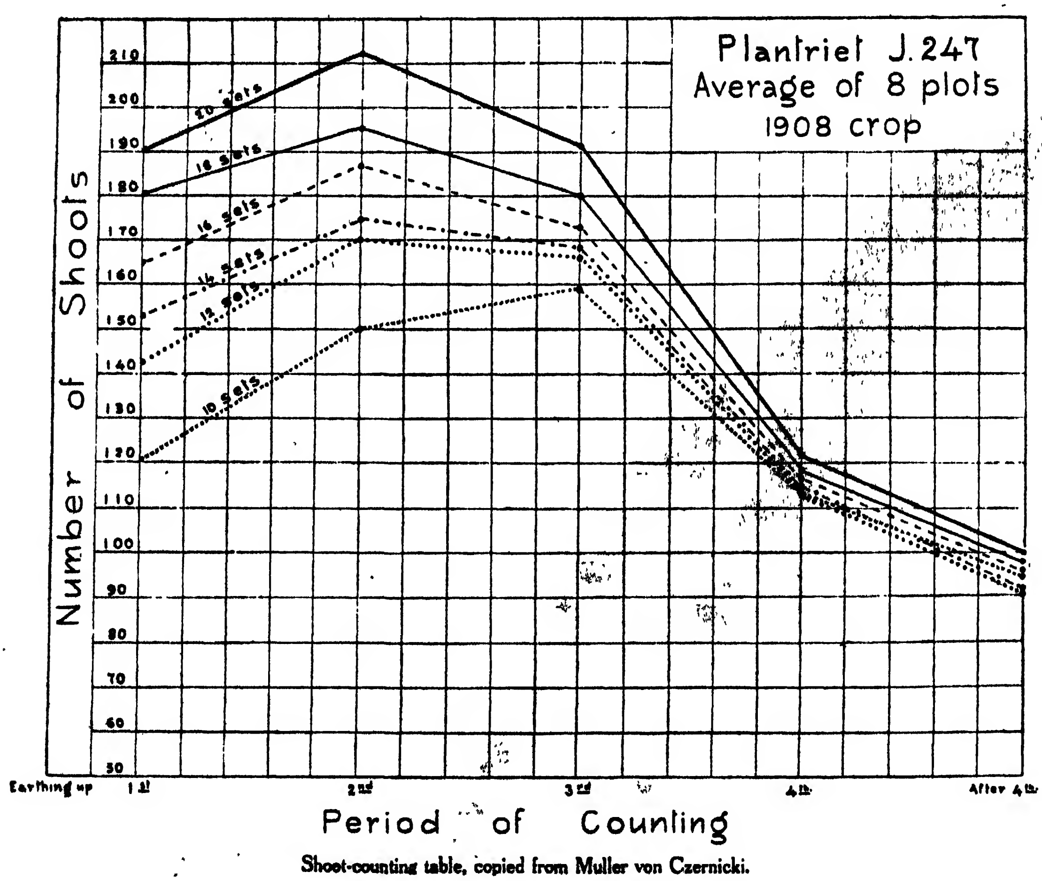


Shoot-counting table, copied from Muller von Czernicki.

had to be imported and was expensive. He accordingly laid down a series of experiments to determine if equally good results could be obtained with a sparser sowing. He also wished to determine the relative tillering power of the different varieties and the time at which the maximum number of shoots was reached. At first he dealt with very large areas, planting them with rows 4 and 5 feet apart. There appeared to be no increase in the number of canes with the wider spacing, rather the reverse, and he decided to concentrate on varying the distance of the plants in the rows. But, in this case also, the results were inconclusive, and this he put down to the varying soil conditions and the impossibility of planting control plots in such large experiments. He therefore instituted a number of experiments on plots one-tenth of a bouw in area (practically 17 tenths of an

[7]Muller von Czernicki, C. F. Proefnemingen omtrent Plantwijdte. *Archief V. D. Suikerind. in Ned. Ind.*, Vol. XVIII, 1910, p. 314.

acre, or as it is termed in Madras, 17 cents). The rows were, as usual, 4 feet apart and about 30 feet long. In these he planted *Black Cheribon, J. 247,* and *J. 100,* varieties which were of importance in his area. The sets were planted 10, 12, 14, 16, 18 and 20 to the row. Countings were made of the shoots above ground at 60, 90, 120 and 150 days from sowing, which, presumably, roughly coincided with the different earthings up; and, 14 days after the last counting of shoots, he counted the canes formed, with a convention which seems to hold in Java of taking two or even three thin canes as the equivalent of one thick one. Muller von Czernicki complains repeatedly of the depredations of thieves and



Shoot-counting table, copied from Muller von Czernicki.

other injuries in his small plots; the presence of *sereh* is also commented on in the plots planted with locally raised seed, but these injuries are of less moment in the early countings, in which we are most interested here, than in the final crop. Numerous tables and graphs illustrate his paper and of these one table and two graphs are reproduced, as the paper is in Dutch and not easily available. In the table one notes with surprise the very early general development of branches from the sets, a steady decline usually following, after the first couple of months. Muller von Czernicki concludes as follows with regard to the three varieties tested:—

THE NUMBER OF SHOOTS COUNTED AT DIFFERENT PERIODS, WITH SETS PLANTED AT DIFFERENT DISTANCES APART—MULLER von CZERNICKI

1908 Crop.

Number of Sets Planted per Row	Number of Plots Avergd	Number of Shoots Counted at: 1st Earthing Up	2nd Earthing Up	3rd Earthing Up	Last Earthing Up	After Last Earthing Up	Crop in Pikuls per Bouw (1¾ Acres)	Sucrose % in the Juice
Generatie Cheribon.								
10		124	122	103	77	61	1,398	15.6
12		138	131	108	77	62	1,416	
14	10	155	147	118	81	66	1,416	
16		178	162	125	85	67	1,404	
18		167	160	124	85	68	1,386	
20		180	170	130	88	72	1,518	15.8
Plantriet No. 247.								
10		120	150	159	114	95	1,728	12.7
12		143	170	166	114	92	1,554	
14	8	153	175	167	115	92	1,452	
16		165	187	173	117	96	1,530	
18		180	196	180	119	97	1,506	
20		190	212	192	122	100	1,536	13.5
Generatie No. 247								
10		161	168	148	122	101	1,536	13.5
12		191	178	155	122	98	1,422	
14	28	203	188	154	120	95	1,446	
16		224	192	160	122	90	1,416	
18		232	202	160	122	95	1,446	
20		240	206	160	124	96	1,410	13.5
Generatie No. 100.								
10		98	128	124	100	82	1,140	16.7
12		124	140	124	104	83	1,200	
14	3	127	148	123	104	83	1,220	
16		142	150	128	104	83	1,220	
18		157	146	126	106	86	1,320	
20		168	156	124	106	86	1,320	15.6

Cheribon has the greatest number of shoots at 60 days, that is at the first counting; in the rows with ten sets the maximum is a little later, but at 150 days from sowing all the plots are approximately equal.

J. 247 tillers more slowly. When planted from sets, the maximum occurs at 90 days, and, in the 10 sets plot, at 120; when planted from tops, because presumably of the greater number of buds, the course of events is practically as in *Cheribon.*

J. 100 (of which only three plots were planted) reached its maximum number of shoots early, the plots with 18-20 sets at 60 days and the rest at 90 days, and after that period there was little difference in the plots.

An inspection of the table and graphs will convince the reader of the greater tillering of the widely spaced plants, where of course there were considerably fewer plants to the row, and the subsequent great mortality of shoots which soon reduced the numbers, till they were more or less uniform in all the rows—all the available light being used up.

The author draws the following conclusions regarding the possibility of reducing the number of sets planted per acre. This is of special importance with the costly imported material, and he points out that, with *Cheribon* and *J.* 100, it can be substantially diminished with safety. This also applied more or less to locally grown seed, but the danger of *serch* is greater and the cost of the seed is much less, so that no change is suggested.

The experiments were repeated in 1909, with 8-20 sets per row, as it seemed to Muller von Czernicki that the lower limits of sowing had not been reached. The results confirmed those of the previous year. In *J.* 100, owing to a mistake, there was only one plot, but in the row with 8 sets a full stand was easily reached.

Muller von Czernicki makes certain observations as to the sucrose content of the mother cane and its branches. He states that some people seem to believe that the mother canes are richer than those developed later, but he cannot find any grounds for this belief. "After many years of observation," he has come to the conclusion that, provided that canes are ripe, there is little or no difference in this respect. He points out that the definition of mother shoots is a very loose one, and quotes Hovenkamp as saying that "mother canes need not be primary stems, but are the thicker and richer canes". We see elsewhere that the assumption is unwarranted, in that the canes of the third order of branching are almost always thicker than the mother canes. And we fail to see in what respect Muller von Czernicki's own deductions are more accurate, in that there are no references to stool dissections, and, without these, it is practically impossible to decide which the mother canes are. He, however, approaches the matter from another point of view. With closely planted sets, he argues, there will naturally be more mother canes than in the widely spaced rows, and this must make its influence felt, if there is richer juice in them, than in the branches; but he has not been able to detect any such difference. Muller von Czernicki's deduction would appear at first sight to be perfectly sound, but he does not go far enough.

Muller von Czernicki states that he has often ~~noted the~~ differences in thickness of canes sparsely and closely planted, especially in the 1909 experiments, and he decided to test this more carefully. He therefore measured 50 canes from

each plot in the following manner, making altogether 1,000 measurements. He used a pair of calipers which he moved round the stem until it encountered the greatest resistance, and took the measurements at about one metre from the ground at the middle of an internode. His results are given in a series of tables, in which the canes are arranged according to their thickness in each plot, with differences in millimetres. From these measurements in thickness he deduced the weight of the canes. By using a formula he calculated the difference in average weight of canes in the rows with 8 and 18 sets, the extremes of the series. This difference varied from 10.5 per cent. in imported *Cheribon* sets, to 17.6 per cent. in local *J. 247*. The average of these differences in the four kinds of seed used was 14 per cent., which means that 86 canes in the thinly sown rows would equal in weight 100 in the closer planted rows. In these deductions he assumes that the plants in the different rows were of equal height, but he himself observes that this was by no means the case; he therefore concludes that for accurate determinations of the weights of individual canes direct weighings will alone suffice.

Struben, in his paper on Tillering (1911), already mentioned, collates numerous countings of canes made by different workers, under the most varying conditions of climate, soil and treatment, and concludes that, within narrow limits, each variety shows the same cane-producing capacity, limits narrow enough not to be of appreciable influence from the crop point of view. He further gives the results of a series of experiments conducted by himself on the lines laid down by Muller von Czernicki. He experimented with *J. 247* and placed 6, 8, 10, 12, 14, 16 and 20 sets in separate rows of the same length, counting the canes at harvest in each case. The following table summarizes his results:—

CANES REAPED AT HARVEST

Sets per Row	J. 100: Heavy Clay		Cheribon: Fertile Land		Cheribon: Infertile Land	
6	74	85	63	68	65	70
8	76	89	69	70	75	80
10	82	89	70	72	82	84
12	85	92	69	76	85	86
14	91	86	72	76	86	85
16	95	86	71	76	86	84
20	94		72	74		

Looking at the figures as a whole, there is a general rise in the number of canes, at first rapid and then slow, as the number of sets per row increases; but this rise appears to receive a check when 12-14 sets per row are reached, and after this there is usually equality or even a slight decline. In only two cases of the six is there anything like a general rise throughout. But the counting of fully formed canes is not a true measure of tillering power, and Struben's figures do not help us in this respect to the same extent as do those of Muller von Czernicki.

The question of tillering power of the canes in the field, and the effect of this upon the harvest, is thus seen to be somewhat complicated. The number of canes

reaped at harvest is connected with the tillering power, but this connection is obscured by the great mortality of shoots during the growth of the plants and is therefore less close than might be expected. Similarly with the weight of canes at harvest, the weight of individual canes in the clump probably varies according to the date of appearance, and the average weight of canes varies with the closeness of planting and the corresponding number of total canes produced. The total yield of sugar depends upon the weight of the individual canes, their number and the richness of the juice. There is some evidence that the amount of sugar in the juice differs in branches of different orders. Spacing the planting material has its influence on all these factors, and it may be useful to summarize the views of the different writers already quoted, and to add such observations on the subject as have been accumulated from time to time at the Cane-breeding Station. The subject will be treated in the following order: The effect of spacing on the tillering power, as judged by the number of shoots produced per clump, and by the number of canes produced per clump at harvest; on the thickness and weight of the individual canes and the total weight of canes reaped; on the total yield of sugar in the crop. A note will then be added on the richness of the juice in branches of different orders in the clump.

(*a*) *Effect of spacing on tillering as judged by the number of shoots produced per clump.* Stubbs, in 1892-93, showed that, by planting the sets at 6″, 12″ and 18″ apart, the number of shoots produced differed a good deal. At three months after planting the 6″ plants had, on the average, 4.1 shoots each, those at 12″ had 5.8 shoots, while those at 18″ had 6.4 shoots per plant. Observations have not as yet been made on this point at the Cane-breeding Station. The following figures have been deduced from those published by Muller von Czernicki and referred to above. We have obtained them by dividing the maximum number of shoots in his countings by the number of sets in the row. The cases selected are the extremes and an intermediate one, namely, where sets were planted 10, 14 and 20 in the row. The following are the maximum numbers of shoots for these spacings: *Cheribon* (tops), 12.4, 11.1 and 9.0; *J.* 100 (tops), 12.5, 10.6, 8.4; *J.* 247 (tops), 16.8, 14.5 and 12.0; *J.* 247 (sets), 15.9, 12.5 and 10.6. The extreme differences in these spacings are roughly as 3 to 2 shoots per plant for the wider plantings.

(*b*) *Effect of spacing on the total number of canes per clump at harvest.* We are able to get more cases in which this has been observed, in that countings of canes at harvest appear to have been made regularly for many years in Java. Stubbs gives the figures for the canes at crop time (seven months from plantings), in Louisiana, and from these we find that the number of canes per clump at 6″ is 2.2, at 12″, 3.7 and at 18″, 4.9. Comparing these figures with those in section (*a*) we see that, although a number of shoots had died, the ultimate differences had increased.

Kilian gives the number of canes at harvest per bouw (1.75 acres) when the rows were 3½′, 4′ and 5′ apart, and we can obtain proportional figures for the number of canes per clump by multiplying these two sets of figures together. It is to be noted that the differences in spacing were not nearly so great as in Stubbs' experiments, but the results are still very definite. Taking the table given

on page 78, we get the proportional numbers as 4.6, 5.0 and 5.9 canes per clump in the richer land and 3.9, 4.3 and 5.0 in the poorer.

Muller von Czernicki does not give the numbers of canes at harvest, but counts them at 5-6 months, using the Java convention of taking two or three thin canes to one thick. Selecting the rows as before with 10, 14 and 20 sets, we get the following figures:—

Cheribon (tops), 6.1, 4.7 and 3.6; *J.* 100 (tops), 8.2, 5.9 and 4.3; *J.* 247 (tops), 10.1, 6.8 and 4.8; *J.* 247 (sets), 9.5, 6.6 and 5.0. Here again there is an increase in the differences in the numbers of shoots produced per plant as the period of harvest approaches, which is not to be wondered at, as the effect of the spacing should be cumulative throughout the growth of the plant.

The same author conducted spacing experiments on a very large scale, the plots extending over 100 bouws (175 acres) with sets planted roughly as 2 to 3 for the same space. This again is a smaller difference in space allowance than Stubbs', but the results are obvious enough. The numbers of canes per bouw are practically equal, showing that the effect of the spacing was that each clump, on the average, produced half as many canes again in the wider planting.

Wider spacing thus has a marked influence on the maximum number of shoots developed per plant; this effect is cumulative, during the period of growth, and is therefore intensified at the time of harvest.

(*c*) *Effect of spacing on the thickness or weight of the individual cane.* Stubbs gives the average weight of cane when the sets were planted 18″, 12″ and 6″ apart, in pounds as 2.60, 2.49 and 2.17. Kilian's results are less conclusive, but the distances apart in the 3½′, 4′ and 5′ rows were very much less. The relative weights in the two tables were as 3.2 to 3.3 to 3.35 and 3.8 to 3.75 to 3.85. There is thus practically no difference in the weights of the canes. Muller von Czernicki dealt rather carefully with the thickness of the cane, and he deduced the weights on the assumption that the canes were of equal heights (which he states from observation is not perfectly correct). He measured the canes at 5-6 months with calipers, in the rows with 8 and 18 sets in them. The result that he obtained from a large number of plots was that the canes in the 8 sets plots were 14 per cent. heavier than those of the 18 sets plots. Other observers, notably Kobus and Van der Stok, emphasize the fact that wider spacing increases the thickness of the individual canes, and it may be considered therefore as incontestable.

(*d*) *Effect of spacing on total weight of canes at harvest.* A wider spacing therefore produces more canes per plant, and these are thicker and heavier. But there are fewer of these plants to the acre. Stubbs gives figures for the total weight of canes reaped, with his spacing of 18″, 12″ and 6″ in the row, as 37.24, 41.6 and 42.55 tons per acre, a distinct though small advantage for the closer planting. Kilian's figures agree, taking the smaller differences into account in his spacing experiments. The total weights of canes in the 3½′, 4′ and 5′ rows were, in pikuls per bouw, 2070, 2056 and 1978 respectively. Muller von Czernicki in his larger plots of 3-5 acres obtained "no advantage in yield by planting widely (5′ instead of the usual 4′), rather the reverse," but the experiments he considered unsatisfactory because of variations in soil and the

impossibility of having any controls. In his carefully controlled smaller plots, again selecting the rows with 10, 14 and 20 sets in them, he gives the following weights of cane reaped in pikuls per bouw, *Cheribon* (tops), 1398, 1416, 1518; *J.* 100 (tops), 1140, 1220 and 1320; *J.* 247 (tops), 1536, 1446 and 1410; *J.* 247 (sets), 1728, 1452 and 1536, respectively. These figures are in favor of closer planting in the *Cheribon* and *J.* 100 plots but in the *J.* 247 they are inconclusive and in fact, have higher yields in both cases with the wider planting. (Has this anything to do with the known greater tillering power of this variety?)

On the whole, there seems to be a general concensus of opinion that wide planting reduces the yield in canes at harvest and the best distance apart will have to be decided for each variety, climate and soil as the result of experiments on the spot. With the generally higher yields of closer planting, it becomes a matter for the balance-sheet, especially where the sets are costly, for the price of the latter may then easily exceed the advantage gained by planting more sets to the acre, as was the case in the Samalkota tract referred to above.

(*c*) *The influence of spacing on total yield of sugar.* The factors of moment in the yield of sugar per acre are very numerous. The variety grown, the climate and soil, the character of cultivation, the efficiency of the manufacturing side, the number of canes per acre and their thickness, and the richness and quantity of juice, are all concerned. It is difficult to quote experiments where the effect of all these factors have been considered, but the various workers have given their opinions and these may be summarized, in that they are in general agreement. Within fairly wide limits, close planting appears to give a greater yield, but this is chiefly where the general level of cultivation is low. The local rate of planting is, in India, frequently excessive. This was clearly shown at Samalkota where the same yield in *jaggery* was uniformly obtained with thick canes by planting half the sets generally used. Similar results were obtained as to the maximum yield of *gur* in the experiments at Partabgarh, where, however, only one local cane was experimented with and that of course with a thin indigenous one. A somewhat similar result appears to have been obtained by Stubbs in Louisiana, for he recommends for the maximum crop the planting of the sets 6″ apart in 5′ to 6′ rows.

As to Java, Kobus lays it down as the result of his observations and experiments that even a difference of 10 per cent. in the number of canes per acre may very well go with the same yield of sugar. From this, we gather that the number of canes, which we have seen to be influenced by spacing, is not too closely connected with the yield of sugar, and therefore that the effect of spacing is of little import within moderate limits. This statement of Kobus is taken up by Struben, who argues in its favor and states that the Editor of the *Archief*, the principal organ of the Java industry, has long held the same view. Kilian's experiment of planting canes in rows, 3½′, 4′ and 5′ apart, gave results from which he gathers that, in *J.* 247, the current distance of 4′ cannot be altered with advantage. In the two controlled experiments on dry loam, the yields of sugar in pikuls per bouw for these spacings were respectively 197, 201, 199 and 210, 206 and 201; while another uncontrolled experiment on heavy black clay gave 162, 181, 158. Muller von Czernicki found, in crop experiments of 3 to 4 acres each over 175 acres, that a spacing varying as 2:3 made practically no differ-

ence as to yield of sugar. We may therefore conclude, that, with good cultivation, the yield of sugar, influenced as it is by so many factors, has no intimate relation to the spacing of the plants, and that this may accordingly vary within moderately wide limits without disadvantage. These limits have to be determined in each place with each variety separately.

Note on the Relative Richness of the Juice in Branches of Different Orders

Kobus has made an oft-repeated generalization, after years of experiment, that, in a cane field, "thicker clumps have heavier canes and richer juice." Van der Stok also asserts that, in a general crop, the thick canes have more sugar in their juice.[8] Stubbs showed that, in the Louisiana crops, the mother canes had richer juice than the branches from it, but he failed to convince us that the earlier branches also had better juice than the later. In Java, writers generally take exception to this imputed superiority of the mother canes, and Muller von Czernicki asserts his conviction that, provided the crop ripens, as it generally does there, there is no difference in the juice of the different orders of branching. This rather discounts the Louisiana results, for a crop reaped at seven months from planting can hardly be considered by cane growers in the tropics as properly matured. But, on the other hand, we have failed to discover any indication that the true character of the branches has been determined in Java. After a good many dissections, we conclude that it would be a very difficult thing, without experience thus gained, to detect which are the mother canes of the crop. There seems, in general, to be a tendency to assume that these are thicker than the rest, but our results are exactly the opposite. We cannot, therefore, think that the opinions on this point either in Louisiana or in Java are altogether trustworthy.

A certain amount of work has been done at various times in the Laboratory of the Cane-breeding Station, on the richness of the juice in the different canes in the clump during growth and at crop time. In our study of early and late canes, we made use of the members of the Pansahi group, because, before we had made our dissections, it was easy to distinguish between the early and late canes. Some of the results of this study have been given in Memoir II, where it is shown that, in several varieties (*Maneria, Kahu, Yuba and Pansahi*), it was easy to separate the different classes of branches at crop time, and that, in their analysis, the earlier formed canes were invariably richer in their juice than the later. At the close of the 1917-18 crop, an attempt was made to divide the cut canes into classes, by observing the characters by which the branches of different orders could be separated, starting with thickness of cane and, where necessary, introducing length of basal part, average length of lower joints, curvature, etc. This separation was, as usual, found to be specially easy in the members of the Pansahi group. One hundred canes were thus dealt with in each of the varieties dissected and these were divided into their appropriate classes and separately analyzed. In *Maneria,* the percentage of sucrose in the different

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8J. E. Van der Stok, in Fruwirth's *Die Zuchtung der Landwirth-schaftlichen Kulturflanzen Zuckerrohr.*

classes from earliest to latest was 14.25, 13.74, 13.63, 13.57, 9.80, and in *Yuba* 15.17, 14.86, 13.14, 12.53 and 12.40.

It appears, from a great number of analyses which we have made at various times, that, while the plants are young, there is a great difference in the richness of the juice in the canes of different orders of branching, but that this difference gradually diminishes as the usual harvesting time approaches; and, when it has passed, that the juice of the earlier formed canes commences to deteriorate until it is distinctly poorer than that of later formed branches, which in their turn approach their optimum. This being the case, there will be a point of time in the life of each clump when the juice in the early and late canes tends to be of about the same richness, a period of equilibrium which may be regarded as the optimum of richness in the juice of the whole clump. It is probable that this point of time will vary in each clump of the same variety, even under the same conditions; it is likely that it will vary more in different varieties of the same group, and still more in the different groups. Besides this, the maximum richness of the juice in the clumps in any variety will naturally depend upon whether it is an early or late maturing kind.

Boiler Heating Surface.*

Engineers have for many years past been in the habit of thinking of ten square feet of water-heating surface as a boiler horse-power, so called. Boilers were formerly not driven much beyond their normal rating and flue-gas temperatures around six hundred degrees Fahrenheit were regarded as consistent with good operation. Any heat-absorbing surface added to recover a portion of the heat lost in the flue gases was generally in the form of a cast-iron economizer and distinct from the boiler itself. Economizer surface is understood to consist of water-heating rather than steam-generating surface.

In recent years the steel-tube economizer has been introduced as well as the so-called integral economizer, which latter forms a portion of the circulating system of the boiler itself. It is generally not difficult in a boiler design embodying integral economizers to designate certain heating surfaces as economizer surfaces, for the arrangement of gas baffles, water circulation, etc., clearly indicate that such surface is essentially water-heating and not steam-generating surface.

Coincident with this development the builders of horizontal water-tube boilers brought out the so-called "high" boiler. Instead of the original nine by twelve tube high boiler, we now have available eighteen, twenty-one and even twenty-four tube high boilers. The high boiler with proper baffles will have lower flue-gas temperature than the old standard boiler with twelve tubes high and therefore, will operate at higher efficiency.

It has been stated that a portion of this added surface acts as a water-heating surface and is in a way equivalent to the surface of an integral economizer. This is not true in the case of practically all types of standard water-tube boilers with tubes inclined only slightly to the horizontal. The feed water in such boilers usually enters at the upper drum, where it comes in contact with the water which has risen from the tubes and which is in a state of ebullition, giving off steam. The feed is almost instantly heated to boiler temperature in the drum and passes down into the circulation system of the boiler along with the other boiler water. The tube surfaces receive only water at boiler temperature and, therefore, can never be considered as water-heating or economizer surface, but as true steam-generating surface.

The high boiler merely exposes additional heating surface to the furnace gases and by lowering the flue-gas temperature increases the boiler efficiency. High boilers cannot be forced to give the same average evaporation per square foot as the old standard boilers. These considerations emphasize still further the illogical definition of ten square feet of heating surface as a boiler horsepower. It seems apparent that engineers must revise their ideas of boiler ratings and consider boiler output, especially when they have the high boiler in mind.

[W. E. S.]

*From "Power," November 14, 1922.

Annual Synopsis of Mill Data, 1922.

By W. R. McAllep.

All factories in the Association have furnished data for this Synopsis. All except eight of the forty-one had finished grinding on October 1, at which time it was necessary to have all schedules forwarded. The unharvested portion of the crop at these factories at the time data were forwarded, approximates 2.5% of the 1922 crop. The tabulated matter is presented in practically the same form as in the last few synopses. Analytical data and true average are in the first of the large tables, details of mill settings, etc., are in the second, and in the third details of surface and juice grooving now in use. Factories are listed in the order of the average size of the crop for the past five seasons.

VARIETIES OF CANE

Varieties of cane ground to the extent of 1% or more of the total crop are tabulated in Table 1. This season the decrease in the tonnage of Lahaina has reduced this variety to fourth in importance, H 109 and D 1135 which were last season third and fourth now being second and third. The proportion of Yellow Caledonia is also diminishing. There is a marked biennial variation in the proportion of this variety and this is the principal factor influencing the comparatively large decrease shown this year. Figures for the last five years, however, indicate a gradual decrease. H 109 shows the largest increase. The proportion of D1135 has consistently increased from year to year. The Tip cane shows a fairly consistent increase.

Varieties included in the column "Other Varieties," that formed 1% or more of the crop at any one factory are:

Variety	% of Total Crop
H 146	0.82
Yellow Bamboo	0.29
H 20	0.17
Badila	0.15
White Bamboo	0.15
H 291	0.03
Total	1.61

H 227 does not appear in the above tabulation, for though the tonnage was the same as that of H 291 it did not make up 1% of the crop at any one factory.

A comparison of Table 1 with the similar table in the Synopsis for 1914, the first year in which such data were compiled, shows the extent of the

TABLE NO. 1.

VARIETIES OF CANE.

	Yellow Caledonia.	H 109.	D 1135.	Lahaina.	Striped Tip & Yellow Tip.	Striped Mexican.	Rose Bamboo	D 117.	Other Varieties.
H. C. & S. Co.	..	47	19	32	..	2	..	..	..
Oahu	5	31	16	39	..	..	..	..	9
Ewa	2	95	..	..	..	..	..	..	3
Pioneer	..	32	2	21	..	41	..	..	4
Waialua	11	17	25	17	..	..	1	3	26
Maui Agr.	4	40	11	23	..	3	17	..	2
Haw. Sug.	2	35	38	9	..	..	..	..	16
Olaa	90	..	10	..	..	..	..	..	..
Honolulu	39	30	5	24	..	..	..	..	2
Onomea	70	..	1	..	29	..	..	..	..
Hakalau	91	..	..	..	9	..	..	..	..
Kekaha	1	1	10	87	..	..	..	..	1
McBryde	33	44	23	..	..	..	..	..	..
Hilo	94	..	5	..	..	..	..	..	1
Lihue	92	5	2	..	..	..	..	..	1
Haw. Agr.	51	..	20	..	..	..	3	..	26*
Wailuku	3	42	3	12	..	31	..	..	9
Makee	97	3	..	..	..	..	..	..	..
Honokaa	24	5	70	..	..	..	..	..	1
Laupahoehoe	51	..	8	..	35	..	..	6	..
Pepeekeo	97	..	..	..	3	..	..	..	..
Waiakea	100	..	..	..	..	..	..	..	..
Kahuku	74	14	3	9	..	..	..	..	..
Koloa	95	1	4	..	..	..	..	..	..
Hamakua	33	1	27	..	8	..	..	31	..
Honomu	98	..	..	..	..	..	..	1	1
Paauhau	58	..	34	..	5	..	..	..	3
Hawi	23	32	18	..	27	..	..	..	..
Hutchinson	41	..	1	..	1	..	57	..	..
Waianae	1	82	..	14	..	..	..	..	3
Kaiwiki	49	..	10	..	25	..	..	15	1
Kilauea	97	..	..	..	..	..	..	..	3
Kohala	22	..	23	..	38	..	..	..	17
Kaeleku	100	..	..	..	..	..	..	..	..
Waimanalo	96	2	..	..	..	..	..	..	2
Niulii	80	..	11	..	9	..	..	..	..
Halawa	50	..	10	..	40	..	..	..	..
Waimea	1	20	3	75	..	..	..	..	1
Olowalu	..	47	..	35	..	18	..	..	..
Union Mill	24	3	6	..	66	..	..	1	..
Kipahulu	100	..	..	..	..	..	..	..	..
True Average 1922	40.3	21.1	12.2	12.0	4.3	2.8	1.6	1.2	4.5
" " 1921	45.1	15.0	11.0	17.4	3.0	3.0	1.0	1.1	3.4
" " 1920	42.7	9.1	10.0	26.7	3.5	2.5	0.8	1.0	3.7
" " 1919	46.4	6.8	7.2	29.1	2.9	1.8	2.1	1.1	2.6
" " 1918	42.9	4.0	7.5	37.9	2.0	0.6	1.1	0.8	3.2

*White and Yellow Bamboo 12%.

tendency to extend the minor varieties over considerable areas. In that year no single minor variety was ground to the extent of 1% or more of the crop, at more than 15% of the factories. The total tonnage, with the exception of a comparatively small proportion, was made up of Yellow Caledonia and Lahaina. This season D 1135, the third most important variety, is reported from 70%, while the fourth and fifth varieties, Lahaina and the Tip canes, are each reported from a third of the factories.

QUALITY OF CANE

The quality of the cane has been poorer than in any previous year, not excepting the low point reached in 1918. The difference between 1921 and 1922, however, is not very great, amounting to slightly over .03 in quality ratio. Juices have been higher in purity than last year, but lower than in any other season. The fiber has been higher than in any previous year.

Table 2 is the composition of the cane by Islands. On Kauai only was the quality better than during the preceding season. On Oahu the quality was practically the same. On Hawaii it was somewhat poorer than last year, but slightly better than in 1918. On Maui it was considerably poorer than in any previous season.

MILLING

The factories are arranged in the order of the size of their milling loss in Table 3. Two factories, Hakalau and Onomea, have bettered the record for milling loss of 1.16 made by Onomea last year. Three factories report milling losses under 1.5 against 5 last year, while 16 report under 3.0 against 21 last year. None of the factories this year secured 99 extraction. Five report better than 98 extraction against nine last year. Marked improvement is reported from the five factories at the bottom of the list. Two factories only report milling losses higher than 5.5 against four last year.

Olowalu, Pioneer, Paauhau, Waialua, and Kaeleku have materially improved their relative standing in the tabulation though only the first two report better work. Ewa, Maui Agricultural Company, Honokaa, and Waianae are materially lower in their relative standing.

This is the first time since 1911 that the milling work has failed to show an improvement over that of the preceding season. The average milling loss compared with last year has increased from 2.64 to 3.02 and the extraction has dropped from 97.43 to 96.98. Figures for milling loss, extraction ratio, and extraction indicate that the quality of the work has been of about the same order as in 1917.

The averages have been considerably affected by lower extractions obtained at three of the larger mills. At one of these the extraction was low because a half of the milling equipment only was available while a considerable portion of the crop was ground. At another ~~on account~~ of operating at higher capacity the cane was ground in two 12-roller tandems while last season one 15-roller tandem was used. Lower extraction at these two, to-

TABLE NO. 2.

COMPOSITION OF CANE BY ISLANDS.

	Hawaii	Maui	Oahu	Kauai	Whole Group
1913					
Polarization	13.22	15.56	14.21	13.70	14.05
Percent Fiber	13.74	11.73	12.75	12.50	12.85
Purity 1st Mill Juice	88.47	91.11	88.20	88.12	89.02
1914					
Polarization	12.75	15.16	14.23	13.62	13.78
Percent Fiber	13.62	11.59	12.44	12.75	12.74
Purity 1st Mill Juice	88.22	91.02	88.11	87.51	88.71
1915					
Polarization	12.61	15.23	14.29	14.09	13.77
Percent Fiber	13.00	11.44	12.77	12.46	12.51
Purity 1st Mill Juice	87.86	90.48	87.27	86.99	88.24
1916					
Polarization	12.54	14.62	13.74	13.26	13.45
Percent Fiber	13.22	12.22	12.51	12.86	12.74
Purity 1st Mill Juice	87.56	89.41	87.15	86.26	87.70
1917					
Polarization	13.31	15.43	13.55	13.13	13.76
Percent Fiber	13.23	11.67	12.25	12.89	12.62
Purity 1st Mill Juice	88.11	90.69	86.86	86.70	88.02
1918					
Polarization	11.88	14.25	13.50	12.54	12.97
Percent Fiber	13.35	11.53	12.23	12.84	12.50
Purity 1st Mill Juice	87.27	88.62	86.93	85.88	87.18
1919					
Polarization	12.74	15.12	14.24	13.52	13.74
Percent Fiber	13.07	11.74	12.14	12.61	12.49
Purity 1st Mill Juice	87.54	88.81	87.00	85.82	87.34
1920					
Polarization	12.86	15.29	13.75	13.07	13.64
Percent Fiber	13.36	11.39	12.65	12.72	12.64
Purity 1st Mill Juice	87.87	88.94	85.40	86.52	87.24
1921					
Polarization	12.25	14.67	13.72	12.67	13.12
Percent Fiber	13.28	11.82	12.40	13.28	12.80
Purity 1st Mill Juice	87.18	87.37	85.46	84.07	86.22
1922					
Polarization	12.07	13.95	13.61	13.03	12.97
Percent Fiber	13.16	12.38	12.88	13.22	12.95
Purity 1st Mill Juice	87.17	87.88	86.18	85.80	86.84

gether with poorer results secured at a third large factory reduce the average to the extent of almost 0.3, or some 60% of the whole decrease. While the decrease in the quality of the milling work has been rather general, 66% of the factories reporting higher milling losses, 62% higher extraction ratios and 72% lower extraction, the averages would have been depressed to a considerably smaller extent had it not been for the lower results secured at these three of the larger factories.

The average moisture in the bagasse has increased from 41.20 to 41.51%. The tendency has not been general, the factories reporting higher and lower bagasse moistures being almost evenly divided.

The pressures carried on the mills are not materially different from those reported a year ago. A half of the factories report the same pressure as before. Nine factories report heavier pressures, while eleven report lighter. Three or four of the latter report moderately large decreases. Taken as a whole the figures indicate a slight tendency toward lighter pressures.

The maceration has been reduced from 39.30 to 34.75, 64% of the factories reporting a decrease in the amount used. While higher moisture in the bagasse tends to indicate some decrease in the efficiency of the mills considered as machines for extracting juice by pressure, it is probable that the comparatively large reduction in maceration is a much greater factor in the poorer results secured.

Conditions during the past year have rendered it particularly desirable to curtail all avoidable expense, and the change in the quality of the milling work is, no doubt, largely a reflection of efforts in this direction. As the reduction in hydraulic pressure has not been general, and in only a few cases has it been enough to be of any consequence, presumably the saving in wear and tear on equipment has been small. The reduction in maceration, however, has been accompanied by a reduction in the amount of extra fuel burned, and in this direction savings in expenditures have been made. Such savings, however, have only been possible at factories where it has been the practice to burn extra fuel. It is significant that the four factories at the head of Table 3 have reported the use of no fuel other than bagasse and molasses either this or last year, and that three of these report improvements in milling. Considering the fiber content of the cane as a measure of the fuel available these factories are not particularly favored, for but one reports a fiber content higher than the average. The results secured at Pioneer are also significant. At this factory the fiber is considerably below the average and formerly extra fuel in considerable amounts was burned. The capacity of the boiling house has been increased and while making the change the evaporating and boiling equipment has been brought to an economical capacity. This together with changes in the boilers and the present method of operation has permitted an improvement in the milling work not only without the use of extra fuel, but with a credit to the mill for power supplied to outside points equivalent to 12% of the total amount of bagasse. It should be noted that in making new installations the extra cost of equipment of sufficient capacity to do the work economically over that of barely sufficient capacity to perform the work is usually but a moderate proportion of the total cost. Theoretically the

TABLE NO. 3.—MILLING RESULTS.

Showing the Rank of the Factories on the Basis of Milling Loss.

Factory	Milling Loss	Extraction Ratio	Extraction	Equipment
1. Hakalau	1.10	0.09	98.84	2RC54,12RM9-60,3-66
2. Onomea	1.15	0.09	98.79	2RC60,S54,12RM66
3. Hilo	1.29	0.11	98.48	K,2RC60,12RM66
4. Pepeekeo	1.88	0.16	98.00	2RC54,9RM60
5. H. C. & S. Co. ..	2.14	0.14	98.19	K(4),2RC78(2),S72(2),12RM78(2)
6. Paauhau	2.34	0.20	97.30	2RC60,12RM66
7. Makee	2.43	0.21	97.06	K,2RC72,S72,9RM72
8. Wailuku	2.45	0.19	97.69	K,2RC72,12RM78
9. Koloa	2.54	0.21	97.09	K,2RC60,12RM66
10. Lihue	2.55	0.21	97.20	K,2RC78,S72,12RM78
11. Pioneer	2.58	0.18	97.79	K,2RC72,S72,15RM72
12. Haw. Sug.	2.62	0.17	97.82	K.2RC72,S72,12RM78
13. Haw. Agr.	2.62	0.22	97.06	3RC60,12RM66
14. Honomu	2.66	0.22	97.34	2RC60,9RM60
15. Olowalu	2.70	0.20	97.53	K,3RC48,9RM48
16. Kilauea	2.73	0.25	96.71	K,S,3RC60,9RM60
17. Waimea	3.04	0.22	97.45	2RC48,12RM42
18. Laupahaehoe ...	3.22	0.26	96.66	K,2RC60,9RM60
19. Waialua	3.32	0.24	96.97	K(2),2RC78,12RM78
20. Honokaa	3.33	0.29	96.27	K(2),2RC66,12RM66
21. McBryde	3.38	0.25	96.43	2RC72,S72,9RM84
22. Olaa	3.38	0.28	96.26	K,S72,12RM78
23. Maui Agr.	3.45	0.25	96.99	K(2),3RC66,18RM66
24. Hawi	3.52	0.26	96.79	K(3),3RC48,12RM3-48,9-54,2RC54, 12RM54
25. Hutchinson	3.75	0.33	95.72	2RC60,9RM60
26. Oahu	3.76	0.26	96.73	K(2),2RC78(2),S72,12RM78(2)
27. Kahuku	3.77	0.32	94.95	3RC60,S54,9RM72
28. Kaeleku	3.77	0.34	95.06	K(2),2RC54,9RM60
29. Kekaha	3.80	0.28	96.59	2RC54,9RM60
30. Ewa	3.95	0.30	96.19	K(2),2RC78,18RM78
31. Waianae	3.96	0.29	96.07	K(2),12RM60
32. Honolulu	4.00	0.29	96.51	K(2),S54,2RC78,9RM78
33. Kohala	4.09	0.32	95.72	K(2),3RC60,9RM60
34. Kaiwiki	4.14	0.33	95.34	K,2RC60,9RM60
35. Waiakea	4.49	0.36	95.18	K,S42,2RC60,9RM60
36. Hamakua	4.54	0.35	95.15	K 2RC60,12RM60
37. Union Mill	5.14	0.42	93.84	K.9RM60
38. Halawa	5.41	0.48	93.48	K.2RC60,6RM50
39. Niulii	7.93	0.65	91.40	K,9RM54
40. Kipahulu	8.16	0.69	90.35	K.5RM3-42,2-54

bagasse, particularly when supplemented with molasses, should furnish sufficient fuel to maintain a high quality of work and the above indicates that with equipment suitable for the conditions at the factory in question and with proper operation, this is also the case in practice.

In the greater number of Hawaiian factories additions have been made to the equipment from time to time. In some cases the changes have conformed to well considered plans, taking into consideration the conditions under which the factory must operate, while in others the results of the changes are installations decidedly faulty from the standpoint of fuel economy. Providing a factory has been supplied with enough cane to operate at a reasonable capacity, whether or not a high quality of milling work has been substantially maintained under conditions involving the reduction of expenses to a minimum, is within certain limits a test of how closely the equipment conforms to sound engineering and thermodynamic considerations, and also as to whether or not previous high extractions have been secured by economical methods. Instances have come to the writer's attention where comparatively minor changes would permit an improvement in the work, or perhaps more accurately stated, with such minor changes a greater amount of useful work could be obtained from a given amount of fuel. At some factories, however, fundamental faults in design, render changes that would put them on a satisfactory basis from the standpoint of fuel economy, a much more extensive undertaking.

Had the quality of the milling work been the same as that of the previous year the average extraction would have been 97.40. The yield has been decreased by the amount of commercial sugar corresponding to the difference between 96.98 extraction and this figure. While the investigation of the yield of sugar from the last extracted juices has not been completed we have more definite information than was previously available on this subject. The experiments on last mill juice now completed and under way strongly indicate that these last extracted juices are at least as valuable for manufacturing purposes as would be inferred from their analyses. This indication has been confirmed in factory practice at Ewa during the past season. Comparison of the periods of low and high extraction, when a part only and the whole of the milling machinery was in use, indicates that the expected recovery due to the higher extraction in the latter period was fully realized. The writer considers 2000 tons of commercial sugar a conservative estimate of the reduction in the total 1922 output due to the lower extraction compared with that of the previous season. Balancing the value of this sugar against the saving in expenses that have resulted in lowering the extraction, would give valuable information.

Attention was called in the Synopsis for last year to the fact that the efficiency of the maceration is low. If this question receives the same study that has been given to other features of the milling work this efficiency will, no doubt, be greatly improved. We have here a most promising field for an improvement in the economy with which a high quality of milling work can be obtained.

As would be expected, with lower extraction the difference in purity between the first and last mill juices has been reduced from 20.33 last year to 17.71 this season. The difference between first mill and mixed juice purity has also been reduced from 3.45 to 3.11. While lower extraction has doubtless influenced the latter difference, detailed examination of the figures fails to indicate that it has been a major factor in bringing about the change. Twenty-seven factories report lower extraction than last year, thirteen of these report smaller differences in purity while fourteen report larger differences than last year; twelve factories report increased extraction and of these six report smaller and six larger differences.

The average differences in the years for which figures are available are tabulated below together with extraction and maceration data:

Difference in Purity between First Mill and Mixed Juices:

Year.	Ext.	Maceration.	Purity Difference.
1914	95.46	33.64	3.01
1915	96.30	35.04	3.49
1916	96.87	39.85	3.11
1917	97.05	39.39	3.14
1918	97.21	38.99	3.19
1919	97.30	40.80	3.05
1920	97.45	39.95	3.37
1921	97.43	39.30	3.45
1922	96.98	34.75	3.11

Changes in the differences tabulated above do not follow very closely changes either in extraction or in the amount of maceration. In 1915, a year in which the extraction was comparatively low the difference is abnormally large. There is an increase in 1920 accompanying a comparatively small increase in extraction and somewhat reduced amount of maceration. The difference in purity becomes still greater in 1921 with practically the same extraction as during the previous year and a further reduction in maceration. In other years the difference has fluctuated within comparatively narrow limits, and the 1922 figure is almost identical with the average of the years other than 1915, 1920 and 1921. These data strongly indicate that in actual practice, other factors have probably affected the difference between the first mill and mixed juice purities more than changes in extraction or in the amount of maceration. The care taken to keep the mills clean and the amount of field trash accompanying the cane are probably among the more important of these factors.

GRAVITY SOLIDS AND SUCROSE BALANCES

These data appear in Table 4. As in previous years when suspended solids in mixed juice has not been reported, it has been estimated as 0.25%.

TABLE NO. 4.

GRAVITY SOLIDS AND SUCROSE BALANCES.

Factory	Gravity Solids per 100 Gravity Solids in Mixed Juice				Sucrose per 100 Sucrose in Mixed Juice			
	Press Cake	Commercial Sugar	Final Molasses	Undetermined	Press Cake	Commercial Sugar	Final Molasses	Undetermined
H. C. & S. Co.	6.8	74.8	15.8	2.6	1.3	89.1	7.7	1.9
Oahu	2.3	79.3	16.7	1.7	0.2	91.4	7.8	0.6
Ewa	5.1	74.7	17.5	2.7	0.2	90.0	8.0	1.8
Pioneer	3.8	78.8	15.9	1.5	0.3	93.3	6.7	—0.3
Waialua	6.9	71.0	17.8	4.3	0.5	87.3	9.1	3.1
Maui Agr.	3.9	77.1	16.9	2.1	1.3	90.7	7.8	0.2
Onomea	5.1	78.2	15.1	1.6	0.0	92.1	6.6	1.3
Hakalau	4.0	78.0	15.2	2.8	0.2	92.0	6.6	1.2
Hilo	5.0	76.1	13.7	5.2	0.3	90.9	6.4	2.4
Haw. Agr.	4.8	76.3	17.2	1.7	0.9	88.9	8.4	1.8
Wailuku	4.9	77.5	16.8	0.8	0.2	91.5	7.9	0.4
Makee	2.3	70.7	22.0	5.0	0.4	86.3	11.0	2.3
Laupahoehoe	3.8	77.2	16.5	2.5	0.2	89.8	8.1	1.9
Pepeekeo	5.0	76.9	15.1	3.0	0.2	92.0	6.3	1.5
Waiakea	4.5	75.8	14.6	5.1	0.2	89.4	7.2	3.2
Hamakua	5.4	70.3	8.8	15.5	1.6	84.2	4.6	9.6
Honomu	5.4	77.4	15.1	2.1	0.3	92.2	6.5	1.0
Paauhau	5.1	75.6	16.7	2.6	0.5	90.9	7.8	0.8
Hutchinson	4.5	74.0	18.9	2.6	0.3	87.3	9.9	2.5
Kilauea	3.8	61.0	28.2	7.0	0.7	77.6	15.2	6.5
Kohala	7.1	74.6	17.0	1.3	0.4	90.8	8.2	0.6

Data for making up these balances have been reported from the same factories as last year. The writer would again point out the desirability of the remaining factories making the necessary determinations so that this more accurate basis can be used for the control. Improvements in methods resulting in greater simplicity and a reduction in the time required, render it comparatively easy to make the change. Balances calculated on a polarization basis are deceptive, for the undetermined loss so found is smaller than it is in reality. An arithmetical average of the undetermined losses shown by the more accurate true sucrose figures in Table 4 is over 0.6 larger than the arithmetical average of the undetermined losses of the same factories on a polarization basis.

BOILING HOUSE RECOVERY

Boiling house recoveries based on polarization and the assumptions noted at the foot of the table, compared with the calculated available sugar appear in Table 5. The use of these assumptions introduces a factor of error, probably not over plus or minus 1%. On this basis recoveries of over 101% on the calculated available indicate the probability of errors in the control, while recoveries of under 99% may indicate such errors or actual losses. Recoveries on available higher than 101% are reported from three factories.

Table 6 is a similar comparison of the factories furnishing the necessary data on the more accurate true sucrose basis. In previous synopses the statement has been made that there would seem to be no reason other than errors in the control, why the recoveries on available in this table should exceed 100%. It would seem that such a statement should be modified, particularly as a third of the factories included in Table 6, this year report recoveries of 100% or more. It is well known that the condensate resulting from evaporating and boiling operations is not pure water. In reboiling molasses at this Station, acid products have always been found in the condensate, and during crystallization gases have usually been given off. Also in many factories, where an increased amount of lime has been used in clarification the presence of ammonia in the condensate is quite apparent. We have no definite information as to the extent to which the volatilization of solids, of which the above is evidence, occurs. Presumably it is greater in amount with a more alkaline clarification. Such volatilization of solids in the evaporators does not affect calculations such as those in Table 6, as they are based on syrup purities. Occuring in subsequent operations, however, volatilization of solids would tend to reduce the molasses produced and to increase the sucrose recovery in proportion to the calculated amount.

CLARIFICATION

For the first time in eight years, with the single exception of in 1918, the increase in purity from mixed juice to syrup has been larger than in the preceding season. The increase, 1.23, is smaller, however, than in any season except 1921. Sixty-two per cent of the factories report larger increases than last year.

TABLE NO. 5.

APPARENT BOILING-HOUSE RECOVERY.

Comparing percent available sucrose in the syrup (calculated by formula) with percent polarization actually obtained.

Factory	Available *	Obtained	Recovery on Available
H. C. & S. Co.	91.32	91.42	100.1
Oahu	91.24	92.04	100.9
Ewa	90.98	91.17	100.2
Pioneer	92.27	93.62	101.5
Waialua	89.38	88.23	98.7
Maui Agr.	90.52	91.89†	101.5
Haw. Sug.	92.37	92.36	100.0
Olaa	90.22	89.29	99.0
Onomea	93.13	92.61	99.4
Hakalau	92.05	92.85	100.9
Kekaha	89.76	89.10	99.3
McBryde	90.19	85.92	95.3
Hilo	91.38	91.25	99.9
Lihue	88.64	90.09	101.6
Haw. Agr.	91.31	89.68	98.2
Wailuku	91.75	91.96	100.2
Makee	86.42	87.27	101.0
Honokaa	89.87	89.02	99.1
Laupahoehoe	91.25	90.63	99.3
Pepeekeo	92.73	92.57	99.8
Waiakea	90.97	90.01	98.9
Kahuku	86.81	84.47	97.3
Koloa	85.26	84.85	99.5
Hamakua	88.72	85.83	96.7
Honomu	92.77	93.04	100.3
Paauhau	91.07	91.23	100.2
Hawi	91.42	84.02	91.9
Hutchinson	89.53	88.31	98.6
Waianae	88.78	85.89	96.7
Kaiwiki	90.27	90.40	100.1
Kilauea	83.65	78.21	93.5
Kohala	91.14	91.33	100.2
Kaeleku	86.28	85.84	99.5
Niulii	89.48	89.82	100.4
Halawa	90.49	85.75	94.8
Waimea	87.20	81.21	93.1
Olowalu	*90.35*	*86.45*	*95.7*
Union Mill	89.98	88.22	98.0
Kipahulu	88.63	86.57	97.7

* In order to calculate the available sucrose it is necessary to estimate the gravity purity of the syrup and sugar. Data from factories determining both apparent and gravity purities indicate that the average correction necessary is the addition of 0.8 to the apparent purity of the syrup and [illegible] to the apparent purity of the sugar. When the moisture in the sugar has not been reported [illegible] has been taken. [illegible] has been used when the gravity purity of the molasses has not been reported.

† Sucrose.

TABLE NO. 6.

TRUE BOILING-HOUSE RECOVERY.

Comparing percent sucrose available and recovered.

Factory	Available	Obtained	% Recovery on Available
H. C. & S. Co.	91.43	90.27	98.7
Oahu	91.30	91.58	100.3
Ewa	91.13	90.18	99.0
Pioneer	92.07	93.58	101.6
Waialua	89.28	87.74	98.3
Maui Agri	90.52	91.89	101.5
Onomea	93.10	92.10	98.9
Hakalau	92.09	92.18	100.1
Hilo	91.17	91.17	100.0
Haw. Agr.	91.38	89.71	98.2
Wailuku	91.82	91.68	99.9
Makee	86.33	86.65	100.4
Laupahoehoe	91.23	89.98	98.6
Pepeekeo	92.61	92.18	99.5
Waiakea	90.74	89.58	98.7
Hamakua	88.46	85.57	96.7
Honomu	92.69	92.48	99.8
Paauhau	90.83	91.36	100.6
Hutchinson	89.59	87.56	97.7
Kilauea	82.96	78.15	94.2
Kohala	91.08	91.16	100.1

TABLE NO. 7.

PERCENT MOLASSES PRODUCED ON THEORETICAL.

H. C. & S. Co.	88.1	Honokaa	95.0
Oahu	90.3	Laupahoehoe	87.4
Ewa	87.9	Pepeekeo	84.4
Pioneer	91.4	Waiakea	74.5
Waialua	81.0	Kahuku	78.0
Maui Agr.	88.9	Koloa	89.6
Haw. Sug.	82.1	Hamakua	36.2
Olaa	93.7	Honomu	89.6
Honolulu	*99.4*	*Paauhau*	*86.2*
Onomea	90.0	Hutchinson	88.6
Hakalau	84.7	*Kaiwiki*	71.5
Kekaha	87.7	Kilauea	81.0
McBryde	94.3	Kohala	94.2
Hilo	72.4	Kaeleku	82.1
Lihue	89.6	*Niulii*	*95.8*
Haw. Agr.	88.9	Waimea	82.9
Wailuku	95.0	Olowalu	91.9
Makee	81.7		

The amount of lime used has increased from 0.074 to 0.084% on cane. Twenty-three factories report larger and eight smaller amounts. Of the factories using more lime, 75% report a better increase in purity than last season, while 60% of the factories using less lime report smaller increases. Factories that used the same amount of lime as the previous season are evenly divided between larger and smaller increases in purity.

The polarization of the press cake is higher than in any year for which the figures have been averaged. The same is true of the weight of press cake, and also the loss of polarization in press cake per cent polarization of the cane. The latter has now increased to over half of one per cent. The increase in the lime used has contributed to the increased loss in press cake, for with more alkaline clarification it has been necessary to filter a greater volume of settlings, thus increasing the work required of the presses. Without doubt also less water has been used in sweetening off for reasons similar to those that have resulted in the reduction in maceration.

Attention is called to the averages at the bottom of the column headed "Increase in Purity" and "Press Cake—Weight per 100 Cane," in the first of the large tables. With few exceptions the increase in purity has steadily diminished from year to year while an equally consistent increase has taken place in the weight of press cake per cent cane. This increase in the amount of press cake may be accepted as a fairly reliable indication of the increase in the amount of cush cush in the juice, for while definite information as to what proportion of the press cake consists of cush cush is not at present available, it is probable that, depending on the conditions at different factories, it amounts to from 60 to 80% of the solids in the cake. The term "cush cush" is here used to designate particles of sufficient size to be removed by screening. Lime and heat dissolve a part of such material. That the addition of impurities to the juice in this manner actually takes place during clarification has been demonstrated in experimental work at this Station. This, with inferences that might be drawn from the figures referred to above, and detailed analyses of figures from individual factories which point strongly in the same direction, leaves little doubt but that the constantly increasing amount of cush cush in the mixed juice has been an important factor contributing to the smaller increases in purity. There is also little doubt but that the increased amount of press cake this season would have been accompanied by a still smaller "Increase in Purity" had it not been for the use of an increased amount of lime in clarification.

EVAPORATION

The syrup was evaporated to a higher density than in any previous year; an improvement in the work from the standpoint of fuel economy. Bringing the syrup to a higher density has required less evaporation per cent cane than in previous years, because of a smaller quantity of mixed juice, the result of decreased maceration.

COMMERCIAL SUGAR

There has been a slight increase in the polarization of the commercial sugar, the figures being 96.75 last year against 96.88 this season. The moisture in the commercial sugar has decreased from 0.92 to 0.87%. The deterioration factor remains unchanged at 0.28, the decrease in moisture being in proportion to the increase in polarization. Experiments have shown that deterioration can take place in Hawaiian sugars with a deterioration factor above 0.25. In sugar of 96.88 polarization, 0.78% moisture corresponds to a deterioration factor of 0.25. A deterioration factor of 0.28 is dangerously near the point where deterioration may be expected.

FINAL MOLASSES

The gravity purity of the final molasses has increased from 38.53 to 38.75, the latter figure being identical with the 1920 average. Higher syrup purities have had a tendency to decrease the amount of molasses, and notwithstanding the higher molasses purity, the weight of molasses per cent cane, and also the loss of sucrose in molasses per cent cane are considerably smaller than last year. Had the molasses purity been reduced to the point reached last year, the recovery of sugar would have been further increased by almost 0.1.

Table 7 shows the molasses accounted for compared with the theoretical amount. The latter has been assumed to be the solids in the syrup less the solids recovered in the commercial sugar. While calculating the theoretical amount of molasses in this way is not free from objection, it gives a satisfactory comparative figure except when undertermined losses are very large. This is the fourth year that Table 7 has been compiled. The figures reported have been more consistent in each succeeding year. This year but five factories report less than 80% of the theoretical amount against ten last year, and for the first time none of the factories report more than 100%.

Applying similar calculations to the averages we find that in 1921, 87.2% of the theoretical amount of molasses was recovered. In 1922 the figure is slightly lower; 86.3%. The difference is not great, but is in the direction that would be expected if the previously mentioned volatilization of solids, presumably greater in more alkaline liquors, takes place to any material extent.

Twenty-one of the forty-one factories weigh the final molasses. Control figures from the others would be more reliable if actual weights instead of weights calculated from measurements were available, for the latter are at best an approximation. Fortunately nearly all of the larger factories are included in these twenty-one that weigh the molasses, and inaccuracies in the figures from the smaller factories, due to measurements, do not greatly influence the true averages.

RECOVERY

Compared with the previous season the recovery per cent polarization of the cane has increased from 85.86 to 87.02, a difference of 1.16 and the boiling

house recovery from 88.03 to 89.68, a difference of 1.65. Some 60% of the higher recovery can be credited to higher syrup purities and 40% to reductions in undetermined losses. These higher recoveries, however, have not quite made up for the poorer quality of the cane, and it has required 8.62 tons of cane to make a ton of sugar this year against 8.61 a year ago.

Last year attention was called to figures showing that during the two previous seasons boiling house recoveries compared with the calculated available had been decreasing, larger undetermined losses being the principal cause. These figures, with the corresponding figures for 1922, and also the undetermined losses, appear in the following tabulation. In calculating the available, the average of the differences between apparent and gravity purities reported from the factories where both are determined, have been used. It should be noted that the available does not necessarily represent the maximum possible recovery, as in calculating the available, the gravity purity of the molasses actually secured has been used. For this reason a reduction in final molasses purity would increase the calculated available. Failure of some of the factories to report molasses separately detracts from the accuracy of the figures for undetermined losses. Figures for 1921 and 1922 are not materially affected. In 1920 and particularly in 1919 a larger number of factories failed to report molasses separately and figures for these years are somewhat less accurate. Previous to 1919 the average undetermined loss could not be calculated with any degree of accuracy.

Year.	Available.	Recovery.	Recovery on Available.	Undetermined Loss.
1919	91.87%	90.96%	99.01%	1.27%
1920	91.17	89.56	98.23	1.76
1921	89.87	88.03	97.95	1.97
1922	90.57	89.68	99.02	1.27

The recovery on available has increased to approximately the value that it was in 1919. As the low grade work, or to be more exact, the purity to which the final molasses is reduced, does not affect the above calculations, it will be noted that the reduction in undetermined loss has been sufficiently large to make up for 0.2 greater loss in press cake and still bring about the improvement in the recovery on available shown above. The results of experimental work at this Station together with observations made at the different factories enable the writer to state that the smaller undetermined loss is principally because the more alkaline clarification has resulted in a reduction in the amount of inversion.

Comparing this year's work with last, factors that have tended to increase the losses are lower extraction, increased loss at the filter presses and slightly higher molasses purity. These less favorable results have been more than offset by a smaller difference in purity between first mill and mixed juices, a better increase in purity during clarification and a large reduction in the undetermined loss. The result has been that though the quality ratio would indicate an increase of .034 in the tons of cane required to make a ton of sugar over that necessary in 1921, the increase has been actually but .01 ton.

Theories are sometimes advanced that high extractions do not improve the total recovery. If such theories are valid it necessarily follows that a decrease in extraction will cause improvements in boiling house work to such an extent that the recovery of sucrose percent sucrose in the cane will not be reduced. Figures in the present synopsis are of particular interest, because as noted above the decrease in extraction has been more than offset by recoveries in the boiling house. The writer has studied the figures in as detailed a manner as available time has permitted to see if evidence could be found to substantiate such theories; that is to see if the improvement in boiling house work can reasonably be credited to lower extraction.

For a reduction in the extraction to bring about better boiling house work it must either cause a reduction in the difference between first mill and mixed juice purities, cause a larger increase in purity during clarification, reduce the loss in press cake, or lower the purity of the final molasses. A decrease of 0.34 has taken place in the difference between first mill and mixed juice purities. If the whole of this difference be considered as an improvement in the purity of the mixed juice due to lower extraction, the extra recovery obtainable on this account would amount to some three-quarters of the extra sugar that could be expected had the extraction been equivalent to that of last year. Figures previously discussed, however, render it extremely doubtful if any considerable part of the reduction in this difference has actually been due to lower extraction. The increase in purity during clarification is larger than last year, but this can hardly be credited to lower extraction. Figures discussed in the paragraph on clarification, together with other available data definitely credit this to the use of more lime in clarification. As both loss in press cake and the final molasses purity are higher than last year these factors need not be further considered in this connection.

The greater part of the improvement in the boiling house work is due to a reduction in the undetermined loss, a factor that does not seem in any way dependent on the quality of the milling work. There is, indeed, ample evidence to substantiate the view that this reduction in the undetermined loss is also for the greater part due to the use of more lime in clarification. Further analyses of the figures might throw more light on the subject, but these can not now be made on account of the limited time available for the preparation of this Synopsis. Such examination as has been made, however, indicates that improved work in the boiling house can be credited to lower extraction only to the extent that the latter may have contributed to the reduction in the difference between first mill and mixed juice purities, the major part of the improvement being more or less directly attributable to better conducted clarification.

FACTORY EFFICIENCY

Table 8 has again been included as the writer considers that such comparisons with standards of work somewhat better than that attained at any of the factories are of value. As some objections to the use of these data as means of comparing the efficiencies of the different factories have been pointed out, the title of the table has been changed from Factory Efficiency to Comparison of Actual and Calculated Recoveries.

The calculations in this Synopsis have been made by A. Brodie assisted by H. A. Cook.

TABLE NO. 8.

COMPARISON OF ACTUAL AND CALCULATED RECOVERIES.

The factories are arranged in the order of the ratio of their recovery to that resulting from 100% extraction, reducing the molasses to 30 gravity purity, and eliminating all other losses. Factories reporting a recovery of over 101% of the available (Table No. 5) are omitted from this tabulation.

No.	Factory	Milling	Boiling House	Over All
1	Hakalau	98.84	98.59	97.55
2	Onomea	98.79	97.64	96.61
3	Pepeekeo	98.00	98.31	96.44
4	Honomu	97.34	98.27	95.84
5	Hilo	98.48	96.75	95.38
6	Haw. Sug.	97.82	97.29	95.32
7	Wailuku	97.69	97.18	95.19
8	Paauhau	97.30	96.92	94.55
9	Oahu	96.73	97.34	94.45
10	H. C. & S. Co.	98.19	95.51	94.01
11	Ewa	96.19	97.33	93.93
12	Kohala	95.72	96.67	92.74
13	Makee	97.06	95.17	92.68
14	Laupahoehoe	96.66	95.54	92.56
15	Kaiwiki	95.34	96.06	91.91
16	Kekaha	96.59	94.94	91.86
17	Olaa	96.26	94.88	91.76
18	Honokaa	96.27	94.81	91.53
19	Waialua	96.97	93.91	91.30
20	Olowalu	97.53	93.30	91.21
21	Haw. Agr.	97.06	93.81	91.20
22	Koloa	97.09	93.19	90.84
23	Waiakea	95.18	95.07	90.80
24	Hutchinson	95.72	93.46	89.76
25	Kaeleku	95.06	93.59	89.21
26	McBryde	96.43	92.10	89.07
27	Waianae	96.07	92.39	89.06
28	Kahuku	94.95	93.12	88.81
29	Niulii	91.40	95.32	87.39
30	Union Mill	93.84	92.73	87.32
31	Hawi	96.79	88.93	86.24
32	Hamakua	95.15	90.39	86.20
33	Waimea	97.45	87.10	85.00
34	Halawa	93.48	90.67	84.95
35	Kipahulu	90.35	92.24	83.68
36	Kilauea	96.70	86.17	83.59

TABLE NO. 9.

SUMMARY OF LOSSES.

FACTORY	POUNDS POLARIZATION PER TON OF CANE						POLARIZATION PER 100 CANE						POLARIZATION PER 100 POLARIZATION OF CANE							FACTORY
	Bagasse	Press Cake	Molasses	Other Known	Undetermined	TOTAL	Bagasse	Press Cake	Molasses	Other Known	Undetermined	TOTAL	Bagasse	Press Cake	Molasses	Other Known	Undetermined	TOTAL	Syrup Purity	
H. C. & S. Co.	5.4	3.8	22.6	...	2.0	33.8	0.27	0.19	1.13	...	0.10	1.69	1.81	1.31	7.64	...	0.67	11.43	86.32	H. C. & S. Co.
Oahu	9.4	0.6	21.6	...	0.2	31.8	0.47	0.03	1.08	...	0.01	1.59	3.27	0.19	7.60	...	0.08	11.14	86.44	Oahu
Ewa	10.2	0.6	20.8	...	1.8	33.4	0.51	0.03	1.04	...	0.09	1.67	3.81	0.21	7.81	...	0.66	12.49	84.58	Ewa
Pioneer	6.2	1.0	18.6	0.2	—1.4	24.6*	0.31	0.05	0.93	0.01	—0.07	1.23*	2.21	0.33	6.62	0.07	—0.47	8.76*	85.49	Pioneer
Waialua	8.4	1.4	24.6	...	6.6	40.1	0.42	0.07	1.23	...	0.33	2.05	3.03	0.47	8.95	...	2.41	14.86	84.6	Waialua
Maui Agr.	8.2	3.4	20.6	...	0.4	32.6*†	0.41	0.17	1.03	...	0.02	1.63*†	3.01	1.25	7.60	...	0.17	12.03*†	85 34	Maui Agr.
Haw. Sug.	6.6	2.0	18.8	...	3.4	30.8	0.33	0.10	0.94	...	0.17	1.54	2.18	0.65	6.31	...	1.12	10.26	85.82	Haw. Sug.
Olaa	9.0	1.2	22.2	...	2.2	34.6	0.45	0.06	1.11	...	0.11	1.73	3.74	0.48	9.29	...	0.96	14.47	85.0	Olaa
Honolulu	9.8	0.4	32.0	0.8	...	...	0.49	0.02	1.60	0.04	...	...	3.49	0.14	11.49	0.30	...	....	85.52	Honolulu
Onomea	3.0	0.2	16.0	..	1.8	21.0	0.15	0.01	0.80	...	0.09	1.05	1.21	0.05	6.53	...	0.77	8.56	87.05	Onomea
Hakalau	2.8	0.4	16.2	...	1.0	20.4	0.14	0.02	0.81	...	0.05	1.02	1.16	0.16	6.62	...	0.44	8.38	85.33	Hakalau
Kekaha	9.4	1.6	24.8	...	4.0	39.8	0.47	0.08	1.24	...	0.20	1.99	3.41	0.62	9.01	...	1.45	14.49	84.19	Kekaha
McBryde	9.6	0.6	28.8	...	7.6	46.6	0.48	0.03	1.44	...	0.38	2.33	3.57	0.23	10.71	...	2.83	17.34	83.74	McBryde
Hilo	3.6	0.6	14.6	...	5.4	24.2	0.18	0.03	0.73	...	0.27	1.21	1.52	0.24	6.32	...	2.28	10.36	85.54	Hilo
Lihue	6.8	1.0	23.2	...	0.0	31.0*	0.34	0.05	1.16	...	0.00	1.55*	2.80	0.43	9.58	...	0.01	12.82*	81.60	Lihue
Haw. Agr.	7.0	2.0	19.6	...	4.2	32.8	0.35	0.10	0.98	...	0.21	1.64	2.94	0.88	8.20	...	1.72	13.74	86.79	Haw. Agr.
Wailuku	6.2	0.4	20.4	...	0.2	27.2	0.31	0.02	1.02	...	0.01	1.36	2.31	0.18	7.74	...	0.10	10.33	86.3	Wailuku
Makee	6.8	1.0	25.2	...	3.6	36.6	0.34	0.05	1.26	...	0.18	1.83	2.94	0.39	10.75	...	1.55	15.63	81.35	Makee
Honokaa	8.6	1.0	22.6	...	1.6	33.8	0.43	0.05	1.13	...	0.08	1.69	3.73	0.45	9.84	...	0.68	14.70	84.44	Honokaa
Laupahoehoe	8.2	0.4	19.4	...	2.8	30.8	0.41	0.02	0.97	...	0.14	1.54	3.34	0.18	7.88	...	1.16	12.56	86.71	Laupahoehoe
Pepeekeo	4.6	0.6	14.4	...	2.6	22.2	0.23	0.03	0.72	...	0.13	1.11	2.00	0.22	6.19	...	1.07	9.48	85.38	Pepeekeo
Waiakea	12.0	0.6	17.2	...	6.4	36.2	0.60	0.03	0.86	...	0.32	1.81	4.82	0.24	6.89	...	2.60	14.55	86.23	Waiakea
Kahuku	11.8	1.4	25.0	...	9.6	47.8	0.59	0.07	1.25	...	0.48	2.39	5.05	0.61	10.60	...	4.05	20.31	79.18	Kahuku
Koloa	7.0	1.8	32.0	...	3.4	44.2	0.35	0.09	1.60	...	0.17	2.21	2.91	0.76	13.21	...	1.38	18.26	79.6	Koloa
Hamakua	12.4	4.0	11.2	...	22.8	50.4	0.62	0.20	0.56	...	1.14	2.52	4.85	1.54	4.36	...	8.91	19.66	84.5	Hamakua
Honomu	6.6	0.8	15.6	...	1.0	24.0	0.33	0.04	0.78	...	0.05	1.20	2.66	0.34	6.35	...	0.40	9.75	86.0	Honomu
Paauhau	6.4	1.0	18.2	...	2.2	27.8	0.32	0.05	0.91	...	0.11	1.39	2.70	0.45	7.58	...	0.91	11.64	84.6	Paauhau
Hawi	8.6	1.2	...	...	41.4	51.2	0.43	0.06	...	...	2.07	2.56	3.21	0.46	...	...	15.40	19.07	85.3	Hawi
Hutchinson	9.6	0.6	21.6	...	3.4	35.2	0.48	0.03	1.08	...	0.17	1.76	4.28	0.30	9.60	...	1.55	15.73	85.54	Hutchinson
Waianae	10.6	1.0	...	...	36.8	48.4	0.53	0.05	...	...	1.84	2.42	3.93	0.37	...	...	13.50	17.80	82.93	Waianae
Kaiwiki	11.6	0.4	17.0	...	5.8	34.8	0.58	0.02	0.85	...	0.29	1.74	4.66	0.20	6.81	...	2.32	13.99	85.40	Kaiwiki
Kilauea	7.2	1.4	32.2	...	13.6	54.4	0.36	0.07	1.61	...	0.68	2.72	3.29	0.66	14.75	...	6.18	24.88	79.2	Kilauea
Kohala	10.8	1.0	20.2	...	0.8	32.8	0.54	0.05	1.01	...	0.04	1.64	4.28	0.42	7.92	...	0.34	12.96	85.4	Kohala
Kaeleku	11.0	1.0	24.6	...	5.2	41.8	0.55	0.05	1.23	...	0.26	2.09	4.94	0.46	11.09	...	2.31	18.80	81.28	Kaeleku
Waimanalo	...	1.0	...	...	...	...	...	0.05	...	...	...	...	...	...	...	...	...	....	....	Waimanalo
Niulii	21.0	0.8	22.8	...	0.0	44.6	1.05	0.04	1.14	...	0.00	2.23	8.60	0.32	9.26	...	0.01	18.19	85.30	Niulii
Halawa	14.8	2.6	...	...	29.6	47.0	0.74	0.13	...	...	1.48	2.35	6.52	1.17	...	...	13.15	20.84	84.06	Halawa
Waimea	7.2	1.2	35.4	...	15.8	59.6	0.36	0.06	1.77	...	0.79	2.98	2.55	0.40	12.64	...	5.60	21.19	83.09	Waimea
Olowalu	6.6	0.6	26.4	...	8.2	41.8	0.33	0.03	1.32	...	0.41	2.09	2.47	0.24	10.06	...	3.12	15.89	82.6	Olowalu
Union Mill	15.0	5.0	...	...	26.2	46.2	0.75	0.25	...	...	1.31	2.31	6.16	2.08	...	...	10.82	19.06	83.4	Union Mill
Kipahulu	23.0	4.0	...	...	28.2	55.2	1.15	0.20	...	...	1.41	2.76	9.65	1.72	...	...	11.90	23.27	82.56	Kipahulu

* A comparison of the available sucrose in the juice with the amount recovered in the boiling-house indicates that there is probably an error in some of the results reported from this factory.

† Sucrose.

Sugar Prices.

95° Centrifugals for the Period

September 16 to December 15, 1922.

Date	Per Pound	Per Ton	Remarks
Sept. 16, 1922...	4.73 ¢	$ 94.60	Cubas.
" 19	4.61	92.20	Spot Cubas.
" [illegible]	4.77	95.40	Spot Cubas.
" [illegible]	4.885	97.70	Cubas 4.87 and 4.90.
" [illegible]	4.96	99.20	Cubas.
Oct. 2	5.0633	101.26	Spot Cubas 5.08, Philippines 5.09, Cubas 5.09 and 5.02.
" 3	5.28	105.60	Spot Cubas.
" 9	5.265	105.30	Spot Cubas 5.25, Cubas 5.28.
" 10	5.31	106.20	Cubas 5.28, Spot Cubas 5.34.
" 11	5.40	108.00	Cubas.
" 13	5.525	110.50	Spot Cubas 5.52 and 5.53.
" 14	5.53	110.60	Spot Cubas.
" 27	5.59	111.80	Cubas 5.53, Spot Cubas 5.65.
" 30	5.53	110.60	Cubas.
Nov. 17	5.59	111.80	Cubas 5.53, Philippines 5.65.
" 20	5.65	113.00	Cubas.
" 25	5.78	115.60	Cubas.
Dec. 15	5.53	110.60	Cubas.

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PLANTERS' RECORD

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Single Eye Plantings as an Aid in Selection

Some of the most important varieties of sugar cane have originated as bud variations. It is reasonable to believe that additional varieties of commercial value may be secured in this way.

In the established varieties, no two stools, nor two stalks in the same stool, or even two eyes on the same stalk, are exactly alike. Variability is the rule in sugar cane rather than the exception. Some varieties are apparently more stable than others, while, in some instances, the frequent appearance of striking bud variations indicates that these varieties are in an active mutating stage.

In close planting, where the sugar cane plants are grown under conditions of severe competition, or where they are grown under poor cultural conditions, it seems apparent that the frequency and range of variability may not be so great as where the individual stools are grown under conditions of wider spacing and where the cultural conditions are most favorable to the individual plant development.

In some of the experimental bud selection progeny studies, it seems apparent that very interesting results may be secured through growing stools from single eyes, by spacing these stools at considerably wider distances in the row than is ordinarily the case in the regular field planting, and by giving these spaced single-eye plantings exceptionally good cultural conditions.

In practice, it seems probable that the three-eye seed pieces can be used to advantage in this experimental work by removing the two weakest or poorest eyes and leaving the best eye for the development of a stool, cutting the seed pieces, wherever possible, so that the best eye is the middle one. These seed pieces can be planted in the ordinary plant rows and spaced in the row one or more feet apart as circumstances warrant.

Some of the advantages of this method of experimental planting of some of the progenies in each variety include:

(1) The opportunity of studying the behaviour of individual stools which are known to be the development of the original growth from a single eye;

(2) The development of the variations in the progenies to the maximum degree and rate of occurrence;
(3) The physical advantage of being able to see the individual stools so that their characteristics can be more easily observed and the apparently desirable variations intelligently selected for further propagation.

It is probable that in every progeny field a small area devoted to spaced stools grown from single eyes is an important aid to bud selection work.

A. D. SHAMEL.

Liming at Pioneer Mill*

By HERBERT WALKER

Acting on the suggestion of Mr. W. R. McAllep of the Experiment Station we have increased the amount of lime used in clarification this year and seem so far to be getting better results. Formerly we limed the cold juice till just alkaline to litmus, trying to make the clarified juice about neutral. At the beginning of this season we gradually increased the lime till the cold juice was decidedly alkaline to litmus but still acid to phenolphthalein. We were planning to install a simple titration apparatus so as to maintain a slight definite acidity to phenol, but tests on a few tanks showed no trouble when the raw juice was slightly alkaline to phenol, and since the first few weeks all our juice has been so limed.

The phenol solution is made from 5 grams phenolphthalein dissolved in about 500 cc. denatured alcohol and made to 1000 cc. with water, then neutralized with dilute sodium hydroxide solution till a permanent pink color appears.

The man at the liming station fills a porcelain casserole with cold limed juice, pours it out again, and to the few drops remaining in the bottom of the casserole adds a drop of phenol solution. We try to lime so that the pink color to phenol is distinct but not excessive. This method of using phenol has proved more satisfactory than trying to observe the color in a test tube or on phenolphthalein paper.

Results. The increase in purity from mixed juice to syrup is 1.17 to date. Since 1913 our yearly average increase in purity has varied from a minimum of 0.25 to a maximum of 0.83. As a check we limed by our old method with litmus during the week ending April 1st. The following comparison shows the effect of so doing:

Week Ending	March 25	April 1	April 8
Lime % Cane	0.0586	0.0446	0.0628
Increase in purity	1.25	0.89	1.24
Limed with	phenol	litmus	phenol

According to laboratory tests made by Mr. McAllep March 24 and 25, the maximum possible increase in purity in mixed juice (obtained by liming to slight

* Presented at the first annual meeting of the Association of Hawaiian Sugar Technologists, Honolulu, November 15-18, 1922.

phenol alkilinity and filtering through kieselguhr) was 1.34 in one test and 1.69 in another.

The gain in purity due to heavier liming is comparatively small, but its effect on the recovery is about equivalent to a reduction in purity of one point in the final molasses.

The undetermined losses to date are 0.58% sucrose in cane, which is considerably less than usual.

No trouble has occurred from excessive scale in the evaporator nor has there been any difficulty in boiling either commercial or low grade massecuites.

Disadvantages. Owing to the greater amount of precipitate removed from the juice, more settling tank capacity is required. We have had no trouble in getting a fairly clear juice, but have had some complaints from the mud press men on account of more juice going to that station along with the mud.

It seems to be a little more difficult to get a low purity final molasses. Actually on account of increased capacity we have managed to keep our waste molasses to date a point lower than last year, but to do this have to run off a molasses of about 96 Brix.

On the whole, we think the advantages of the extra lime outweigh the disadvantages, and we expect to continue this method through the year. If the undetermined losses continue to decrease, as they have so far, the gain in total recovery will more than offset any increased filter press and molasses losses.

Cane Varieties in Australia.

In The Australian Sugar Journal of November 3, 1922, H. T. Easterby, Director of the Sugar Experiment Bureau, writes:

> "The beneficial results of the work undertaken at the Experiment Station in the constant introduction and selection by cropping and chemical testing cannot be over-estimated. No cane has a perennial existence. Sooner or later, if constantly grown, it is bound to fall a victim to disease, and the Bureau must be on the constant lookout for new canes. That only a few canes of commercial value can be obtained from large numbers tested is, of course, well known. Out of many thousand seedlings raised in Queensland, only a few were finally selected. In Barbados over one million seedlings were raised, yet only four are in general use. At Demerara the same story obtains, there being only some seven canes that are of value out of considerably over a million raised. The farmer cannot undertake this work for himself, and must look to the Experiment Station for the introduction of new canes. A very great expenditure in time and money is thus saved to the grower. If no more had been done than the introduction of the two canes, Badila and Goru, into Queensland, it would have amply justified all the money that has so far been spent on sugar work."

[J. S. B.P., Jr.]

Potash in Cane Juices.

By HERBERT WALKER AND GEORGE B. GLICK

In a former article* the determination of plant food ingredients in cane juices was suggested as an aid in determining the fertilizer requirements of soils and the results of a number of analyses were given, showing a relationship between the phosphoric acid content of cane juices and that of the soil from which they were derived. We have lately extended this general idea to include the determination of potash as well. The customary method of weighing potash as the chlorplatinate requires more time and attention than can usually be afforded in a sugar factory laboratory. Sherill's centrifugal method, (Foot note—Sugar, Vol. 23, Nos. 5 and 6) modified for cane juices as follows, was found to be much more rapid and fairly accurate. The determination is based upon the relative volumes of precipitates formed from two solutions, the potash concentration of one of which is known.

REAGENTS AND APPARATUS

Standard 1% K_2O Sol.

Weigh carefully 15.83 gm. of C. P. Potassium Chloride, dissolve in distilled water in a liter volumetric flask, add 8 or 10 drops of glacial Acetic Acid and dilute to 1000 cc. with dist. water.

Sodium Cobaltic Nitrate Stock Sol.

To 225 gm. C. P. Sodium Nitrite ($NaNO_2$) add 400 cc. dist. water and allow to stand over night with occasional stirring. At the same time dissolve 125 gm. C. P. Cobalt Acetate in 400 cc. dist. water.

When the Sodium Nitrite is all dissolved pour the Cobalt Acetate into it and mix thoroughly by pouring repeatedly from one beaker to the other. Then dilute to 1000 cc. with dist. water.

This solution keeps very well for several months. A precipitate may form on long standing but has no harmful effect, as it entirely dissolves when the stock solution is diluted and acidified for use.

Sodium Cobaltic Nitrite Sol. for use.

To 100 cc. of stock sol. add 65 cc. dist. water and 5 cc. glacial Acetic Acid. Mix by shaking and allow to stand over night in a loosely stoppered bottle. Sodium Cobaltic Nitrite does not keep very well after it is acidified, so it is best to make up only enough for one day's supply at a time.

Centrifuge.

A Babcock milk-testing hand centrifuge with a four tube head and fitted with cork liners to take potash centrifuge tubes. Braun-Knecht-Heimann Cat. No. 4344 will answer the purpose well.

Potash Centrifuge Tubes.

These can be obtained from Braun-Knecht-Heimann. They should be calibrated before using. Using a 1 cc. pipette graduated to 1/100 cc. transfer 3/10 cc. of Mercury to one tube. By using the capillary tube for washing (described later) the mercury can be made to go down into the stem. The 3/10 cc. should fill the tube to the 15 mark.

* Record Vol. XXVI, p. 317.

Transfer this mercury through a funnel from one tube to another. Record calibrations and compute factors where necessary.

Capillary Tube.

This is drawn from 1/8 inch glass tubing to about 4 inches in length. It should be connected to a large wash bottle and is used to wash the precipitates out of the tubes.

PROCEDURE

Determine the degree Brix of the juice and from this the sp. gr.

To about 500 cc. add milk of lime to faint Phenolphthalein alkalinity. Heat just to boiling and filter through a dry Buchner funnel, using suction. Pipette 150 cc. of the clarified juice, which must be bright and free from suspended and colloidal matter, into a 400 cc. beaker. Evaporate to less than 50 cc. on water bath or hot plate. Transfer to a 50 cc. volumetric flask, add 2.8 cc. of glacial acetic acid and make up to 50 cc. after cooling to room temperature, which should be above 72 F.

Transfer 17 cc. of the Sodium Cobaltic Nitrite sol. to each of two potash centrifuge tubes. Be sure that the stems are full of water and contain no air bubbles before adding the Nitrite sol.

To one tube add 5 cc. of the standard 1% K_2O sol. and to other 5 cc. of the prepared sample. Centrifuge at once for one minute at 1000 r.p.m. Allow the machine to come to a stop, remove each tube, level the precipitate by tapping the stems gently with the finger, replace in the machine, and centrifuge for 15 seconds more. Read and record results.

$$\% \ K_2O \ :: \ \frac{50 \text{ X Reading of Sample.}}{150 \text{ X Sp. Gr. Juice X Reading of Standard.}}$$

Juices which are very low in K_2O and which do not give a reading sufficiently close to that of the standard to be reliable should be run again, using 10 cc. of the sample in one tube and 5 cc. of the standard K_2O sol. with 5 cc. of dist. water in the other. In this case, the formula gives twice the % K_2O in the juice.

The standard K_2O sol. does not give constant readings, due to temperature differences and the age of the Sodium Cobaltic Nitrite sol. Hence it is necessary to run a tube of the standard with every sample, or set of samples.

It is essential that the concentrated sample be bright and contain no precipitated or suspended matter after the acetic acid is added. If this is not the case, further clarification must be obtained by acidifying the filtrate from the lime clarification, heating and again filtering before taking the 150 cc. for analysis.

For comparative purposes the specific gravity of the juice may be neglected and results expressed as grams K_2O per 100 cc. juice.

We have started a complete phosphoric acid and potash survey of all our fields, based on analyses of crusher juice samples. Present indications are that none of our fields are in need of potash and that we shall probably be unable to derive a "safe minimum" figure from the juices of canes grown on this plantation. We have, however, found distinct and constant differences in the amount of K_2O in juices from different fields.

The effect of potash fertilization in increasing the K_2O content of cane juices is shown by the following tests of juices from Plant Food Experiment No. 4, Crop of 1923, a field experiment laid out to determine the increase in yield of sugar due to potash and phosphoric acid. The plots tested had received 200# nitrogen per acre, no phosphoric acid and either 0 or 200# potash. The cane

lacked several months of being ready to harvest. Three stalks were taken from each plot and run through a hand mill. The juices were analyzed as follows:

VARIETY—STRIPED MEXICAN

C Plots—No K_2O

Plot No.	% K_2O	% P_2O_5
128 C	.115	.012
138 C	.088	.010
148 C	.073	.008
136 C	.078	.017
132 C	.082	.017
142 C	.065	.015
152 C	.056	.010
Av.	.0796	.0127

J Plots—200 lbs. K_2O per acre

Plot No.	% K_2O	% P_2O_5
141 J	.088	.010
131 J	.167	.012
151 J	.181	.017
161 J	.158	.012
145 J	.173	.015
137 J	.083	.008
147 J	.114	.010
157 J	.187	.015
Av.	.144	.0124

Although there is considerable variation among the individual analyses which would be expected from the small samples used, the average juices from the K_2O plots are distinctly higher in this element. Since this field showed no decided gain from either potash or phosphoric acid when previously harvested in 1921, it seems probable that the canes from all plots have taken up a sufficient amount of these ingredients from the soil.

A similar test was made on canes from an experimental field in Olaa plantation. These soils have always given an increased yield from potash fertilization.

CANE FROM OLAA

Variety — Yellow Caledonia

Analysis of Juices from small hand mill — No K_2O

Sample No.	% K_2O	% P_2O_5
1	.028	
5	.027	
9	.057	.030
13	.048	
17	.050	.034
21	.049	.035
25	.021	.032
Av.	.040	.033

200 lbs. K_2O per acre

Sample No.	% K_2O	% P_2O_5
4	.074	
8	.076	
12	.104	.035
16	.137	.032
20	.119	
24	.099	.032
Av.	.101	.033

This series shows still more strongly the effect of fertilization on the amount of potash in the juices. The figures for P_2O_5 are given as an additional check on the effect which local variations in soil or cane might cause. Neither series showed any apparent influence of potash fertilization on the P_2O_5 content of the juice.

Reasoning from the two experiments the opinion might be hazarded that a cane juice containing less than 0.05% K_2O indicates the need of potash fertilization, and that one containing 0.10% K_2O probably does not. Whether these or any figures may be generally applicable or whether they may have to be modified for different cane varieties and localities will require a much more extended investigation to establish.

Effect of Nitrogen on Early Growth of Cane.

Sugar cane can use nitrogen applications to good advantage at a very early stage of growth.

The difference in the two cane plants, here shown, is due to the fact that the one on the right received nitrate of soda when it was 37 days old (from date of planting). The picture was taken when the plants were 89 days old. The difference in growth came about, therefore, in 7½ weeks.

The results obtained here in concrete tubs are in keeping with field observations which are pointing with increasing emphasis to the value of early fertilization. It has customarily been the practice to allow a field to reach a good stand and attain a growth of 12 to 18 inches before applying fertilizer.

At the Waipio substation, acting on the recommendations of Mr. Paris, we are applying nitrate of soda at the rate of 50 pounds of nitrogen per acre to plant cane at a month from planting, to ratoons at two weeks or less from the time the field is cleared of the previous crop. This calls for the fertilization of ratoons either with or ahead of the first irrigation.

The results are pleasing. The cane gets a quick start, and closes in at an early date. To what extent, if any, the time of this first application should vary under different climatic conditions has not yet been investigated.

The two cane plants in the picture are being employed in a test to determine the limits to which one may go in applying nitrate of soda and sulphate of ammonia without bringing injury to the crop. Most experiments have dealt with the economic limit. From this test, which Mr. Stewart is conducting in

concrete tubs, we are to learn the point at which these nitrogen salts cease to be an aid to plant growth and become an actual detriment.

Nitrogen is being applied in different tubs each month at the rate of 0, 25, 50, 100 and 200 pounds of nitrogen per acre.

The cuttings (a single eye remaining on a three joint section) were planted in flats September 20, 1922. They were transferred to the tubs without disturbing the roots on October 11, 1922. The plant on the left had no fertilizer, the one on the right had nitrate of soda at the rate of 25 pounds per acre on October 27, 1922, and the dose was repeated November 27, 1922. The photograph was taken December 8, 1922.

H. P. A.

The Effect of Phosphoric Acid and Potash on the Quality of Cane Juices.

By J. A. Verret

During recent years the average quality of cane juices on the different islands has shown a downward tendency. The question has been raised as to whether our systems of fertilizing were in any way responsible for this. With this in mind we have recently made a rather careful review of all our fertilizer experiments and compared the juices from the plots receiving different fertilizer treatments. In this paper we are reporting the results of this study in regard to the effect of phosphoric acid and potash.

The Action of Phosphorus and Potassium on Plants

Before going into the details of the results of our experiments here, we shall give briefly the effects produced on crops by these two elements as given in the literature. These general conclusions given by the different authors are based almost entirely upon temperate zone plants, mainly cereals.

Phosphoric acid is very beneficial in favoring the rapid development of young plants by stimulating the growth of roots. This points to the importance of the early application of phosphates.

Protoplasm cannot exist without phosphorus, and as there can be no plant growth without protoplasm this is very important.

Phosphates are reported to favor the early ripening of crops. The formation of grain is hastened by the free application of phosphates. This maturing effect of the phosphates is due to this hastening of seed formation. Phosphorus is always found more abundantly in the seed than in other parts of the plant. In non-seed crops this maturing effect may not be evident.

Potassium compounds are necessary in order that a plant may produce starch, sugar, cellulose and other carbohydrates. Potassium seems to be necessary for transference of starch from the leaves to other parts of the plant. Potash plays a large part in the development of leaves and the woody parts of the stems of plants. Larger portions of potash are found in these parts of plants. Large amounts of potash tend to prolong the life of plants, thereby delaying maturity, and thus having an effect directly opposite to that of phosphoric acid. Here we have an indication of the importance of early application of potash compounds in order that the potash needed may be used as early as possible and give time for the plant to mature. Potassium compounds give the plant more resistance to the attacks of fungous diseases, such as rusts, especially. Crops not receiving enough potash seem to be more susceptible to diseases of all kinds.

Experimental Results

The results herein reported are based on a total of 84 experiments, covering all the islands and extending from 1917 to 1922.

Each experiment consisted of from 5 to 12 repetitions of each treatment. In nearly all cases, all plots were sampled, and the juices averaged for each treatment. The figures given are the average of several hundrd juice analyses, composed of over a thousand samples, and it would therefore seem that the results obtained can be accepted as more or less conclusive.

The results show no effect whatever on the quality ratio of juices from the use or omission of either phosphoric acid or potash or both. This statement has no reference to the effect of phosphoric acid on the clarifying properties of a cane juice. Recent work by Walker of Pioneer Mill Company and McAllep of this Station points to the fact that the phosphoric acid content of a cane juice has a very important bearing in factory work. When below a certain minimum of phosphoric acid, juices clarify rather poorly. What that minimum is, or its relation to the phosphoric acid content of the soil, is not yet clearly established, as some obscure points remain to be worked out. For instance, the juice from certain fields may be rather low in P_2O_5 and not clarify very well, yet the cane fails to respond to phosphate applications.

Below we give in tabular form a summary of the results obtained from the different treatments:

PHOSPHORIC ACID

	Quality Ratio of Juice	
	Phos. Acid	No Phos. Acid
Average of all experiments responding to phosphates......	8.30	8.29
Average of all experiments not responding to phosphates..	8.46	8.40
Average of all	8.39	8.35

POTASH

	Quality of Juices	
	Potash	No Potash
Average of all experiments responding to potash applications	8.12	8.14
Average of all experiments not responding to potash application	8.24	8.17
Average of all	8.18	8.16

PHOSPHORIC ACID AND POTASH

	Quality of Juices	
	Phos. acid & Potash	No Phos. acid & Potash
Average of all experiments responding to phosphoric acid and potash	8.24	8.18
Average of all experiments not responding to phosphoric acid and potash	7.36	7.30
Average of all	7.92	7.86

The above results show that in arriving at the cause of our poorer juices we must look elsewhere than to the presence or absence of phosphoric acid or of potash in our fertilizers.

Some of these causes may be adverse climatic conditions, change of cane varieties, late harvesting, late fertilizing, increased nitrogen applications, increased yield of cane per acre, or age of cane when harvested.

Some of the above factors we can control, others we cannot. When Lahaina refuses to grow we must change to another variety of cane, even though the juices be poorer. We cannot do much with climate, but we can fertilize earlier.

With our present labor conditions, late harvesting is to be expected. Beginning in July, cane juices go back very fast. But this "going back" seems to apply to old cane in a much greater degree than it does to younger cane—that is cane 24 to 30 months old seems to deteriorate much more than is the case with cane 15 to 18 months old. Our best juices last year at Waipio were from short ratoons harvested in late August. We do not believe that these short ratoons had deteriorated at all when harvested.

We feel that this question of short ratooning is a very important field for more extensive experimentations on the plantations.

We would suggest the trial of short ratooning to the extent that all cane ground from July on, be short ratoons.

There is a possibility that the sugar made from this younger cane late in the year would have a better refining value than sugar made from older, deteriorated cane. Deterioration of cane is accompanied by more or less gum formation, and this, in turn, has a direct bearing on the filtering quality of the sugar.

In another paper we intend to take up the relation between nitrogenous fertilization and cane quality.

QUALITY OF JUICES IN PHOSPHORIC ACID EXPERIMENTS

	Quality Ratio of Juice		Gain from
Experiment	Phos. Acid	No Phos. Acid	Phos. Acid
Kilauea #5, 1917	9.50	9.38	No
Pepeekeo #1, 1917	7.08	7.02	No
Kilauea #7, 1918	8.58	8.54	No
O. S. Co. #6, 1918	9.50	9.53	Yes
O. S. Co. #6, 1920	7.02	7.02	Yes
O. S. Co. #6, 1922	8.24	8.66	Yes
Grove Farm #6, 1919	8.11	7.95	No
Hakalau #4, 1919	8.12	8.19	No
Hakalau #7, 1919	7.58	7.67	No
Honomu #1, 1919	8.73	8.57	No
Paauhau #12, 1919	8.02	8.01	Slight
Paauhau #12, 1921	9.43	9.48	Yes
Kilauea #27, 1921	9.40	9.20	Yes
Kilauea #17, 1920	9.71	9.62	No
Kilauea #17, 1922	11.40	11.12	No
Kilauea #34, 1921	8.68	9.04	Yes
Kilauea #35, 1921	8.87	8.92	Yes
Lihue #1, 1921	8.91	8.71	No
Lihue #2, 1921	8.80	8.92	No
M. A. Co. #8, 1921	8.99	8.71	No
Pioneer #3, 1921	7.27	7.18	No
Pioneer #4, 1921	6.71	6.71	Slight
Waipio V, 1917	8.94	8.89	No
Waipio V, 1918	9.29	9.46	No
Waipio V, 1919	8.53	8.54	No
Waipio V, 1921	9.15	9.15	No
McBryde #2, 1919	7.48	7.42	No

Experiment	Quality Ratio of Juice — Phos. Acid	Quality Ratio of Juice — No Phos. Acid	Gain from Phos. Acid
McBryde #2, 1921	7.51	7.23	No
Onomea #9, 1919	7.55	7.81	No
Onomea #9, 1921	7.40	7.19	No
O. S. Co. #4, 1922	8.95	8.72	Yes
O. S. Co. #14, 1920	7.11	7.11	Yes
H. C. & S. Co. #7, 1921	6.76	6.79	Yes
H. M. Co. #5, 1922	7.58	7.47	No
H. M. Co. #3, 1922	7.24	7.27	Yes
G. F. #9, 1922	7.92	8.33	Yes
H. A. Co. #2, 1922	8.26	8.29	Yes
Kilauea #29, 1922	11.43	10.79	Yes
Kilauea #30, 1922	8.19	7.76	Yes
Lihue #6, 1922	8.40	8.00	Yes
Lihue #7, 1922	7.70	7.80	Yes
Averages	8.39	8.35	
Averages of experiments which responded	8.30	8.29	
Averages of experiments which did not respond	8.46	8.40	

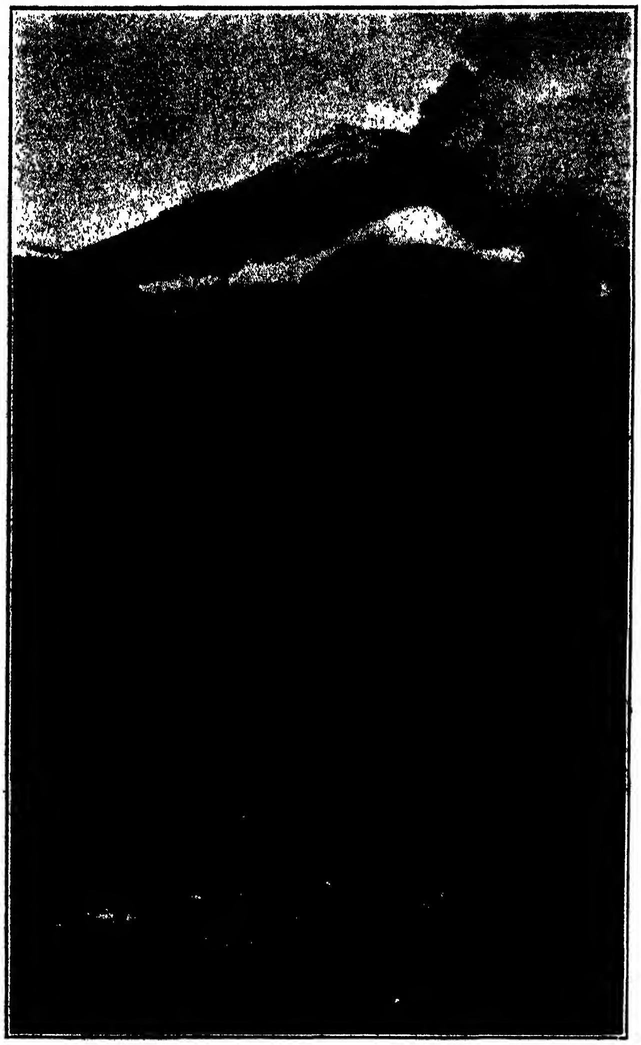
QUALITY OF JUICES IN POTASH EXPERIMENTS

Experiment	Quality Ratio of Juice — Potash	Quality Ratio of Juice — No Potash	Gain from Potash
Onomea #6, 1918	8.42	8.27	Yes
Onomea #6, 1920	8.64	8.58	Yes
Onomea #6, 1922	7.95	7.77	Yes
Onomea #8, 1919	7.61	8.11	Yes
Onomea #8, 1921	8.67	8.56	Yes
Kilauea #23, 1920	9.58	9.94	Yes
Kilauea #24, 1920	9.73	9.73	Slight
Honokaa Obs. B, 1921	7.40	7.65	Yes
Kilauea #25, 1921	8.30	8.29	Slight
Pioneer #4, 1921	6.70	6.73	Slight
Hamakua #5, 1922	7.74	7.30	No
Kilauea #31, 1922	9.58	9.55	No
Oahu S. Co. #8, 1922	8.60	8.64	No
Pepeekeo #6, 1922	8.05	7.88	Yes
Onomea #11, 1922	7.71	7.25	Yes
Waipio V, 1917	9.00	9.11	No
Waipio V, 1918	9.37	9.12	No
Waipio V, 1919	8.68	8.29	No
Waipio V, 1921	9.18	9.13	No
McBryde #2, 1919	7.53	7.43	No
McBryde #2, 1921	7.24	7.46	No
Onomea #9, 1919	7.62	7.91	Yes
Onomea #9, 1921	7.32	7.27	Yes
Oahu S. Co. #4, 1920	7.41	7.46	No
Oahu S. Co. #14, 1920	7.13	6.89	No
H. C. & S. #7, 1921	6.78	6.80	No
Lihue #2, 1921	8.81	8.78	No
M. A. Co. #8, 1921	8.85	8.90	No
Lihue #7, 1922	7.65	7.76	No
Averages	8.18	8.16	

Experiment	Quality Ratio of Juice: Potash	Quality Ratio of Juice: No Potash	Gain from Potash
Averages of all experiments responding to potash	8.12	8.14	
Averages of all experiments not responding to potash	8.24	8.17	

QUALITY OF JUICES IN PLANT FOOD EXPERIMENTS

Experiment	Nitrogen, Phos. Acid and Potash	Nitrogen only	Gain from Phos. Acid and Potash
Waipio V, 1917	9.59	9.53	No
Waipio V, 1918	9.41	9.54	No
Waipio V, 1919	8.06	7.90	No
Waipio V, 1921	9.15	9.15	No
McBryde #2, 1919	7.53	7.42	No
Onomea #9, 1919	7.77	8.14	Yes
Onomea #9, 1921	7.34	7.08	Yes
O. S. Co. #4,1920	7.88	7.56	Yes
O. S. Co. #14, 1920	7.11	7.00	Yes
H. C. & S. Co. #7, 1921	6.76	6.80	No
Lihue #2, 1921	8.92	8.78	No
Maui Agri. Co. #8, 1921	8.71	8.98	No
Pioneer #4, 1921	6.71	6.73	Yes
H. M. Co. #5, 1922	7.78	7.23	No
Lihue #7, 1922	7.80	7.80	No
Averages	7.92	7.86	
Averages of experiments which responded	8.24	8.18	
Averages of experiments which did not respond	7.36	7.30	



CANE FIELDS AT HIGH ALTITUDE.

This photograph was sent by Dr. F. X. Williams from Ecuador. It shows the village of Baños surrounded by cane fields at 6,000 feet elevation. In the background is seen the active volcano Tunguragua rising to a height of 17,000 feet.

Quality of Cane.

By W. R. McAllep

During the preparation of the last annual synopsis, figures for quality of cane that had been reported for previous synopses were compiled. From these data quality ratios of the cane for each island and for the whole group were calculated for the years 1908 to 1922 inclusive. This is arranged in graphic form in figure 1. In calculating these quality ratios the actual polarization of the

cane was used instead of 80% of the polarization of the first extracted juice; the figure usually assumed as the polarization of the cane in the ordinary calculation.

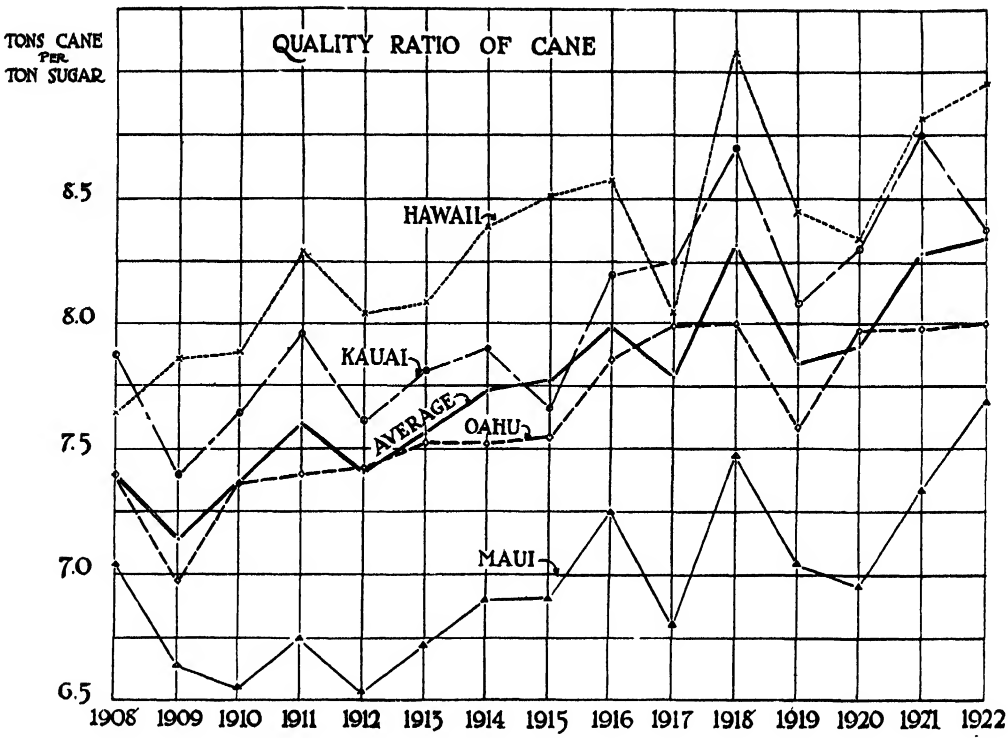


Fig. 1.

The extent that the quality of the cane has been going back from year to year is shown quite clearly by this graph. The following comments apply more particularly to the general slope of the curves than to the seasonal variations in quality for single years. The curve representing the average quality ratio for the whole group indicates that the best quality ratio was in 1909 and the poorest in 1922. Between these years the change is fairly consistent, amounting altogether to an increase of 1.2 tons of cane per ton of sugar. The line representing the Island of Hawaii shows a fairly consistent increase in quality ratio during the whole of the 15 year period. On Kauai during the first half of the period, no definite change in quality is indicated. Subsequent to 1915, however, the quality ratio materially increased. It is rather difficult to decide how much this increase amounts to and what the present tendency is because of irregularity in the last few years, due to large seasonal variations. On Oahu the quality was much better in the year 1909 than in other seasons. With the exception of this one season, from 1908 to 1915 there is a gradual but very small increase in quality ratio amounting altogether for the seven years to about one-tenth of a ton of cane per ton of sugar. During the next two years it increased approximately half a ton. Since that time, however, there has been no further increase. On Maui the quality improved during the first five years of this period. Since that time there has been a large increase in the quality ratio.

Maui has throughout the period been first in quality of cane, then Oahu, usually somewhat better than the average, next Kauai and last Hawaii. This has been the order with but two exceptions throughout the entire fifteen year period. The exceptions were that in 1908 and 1917 the cane on Kauai was of poorer quality than that on Hawaii.

The cane on Maui, Kauai and Hawaii shows a marked tendency to follow similar seasonal variations. These seasonal variations are much less pronounced on Oahu and in but a few instances only does the curve for this island indicate the same seasonal variations shown by the curves for the others.

Possibly the most interesting feature shown by figure 1 is that on Oahu, deterioration in the quality of the cane has apparently been checked, the curve for the last six years showing little if any tendency towards a decrease in quality of cane.

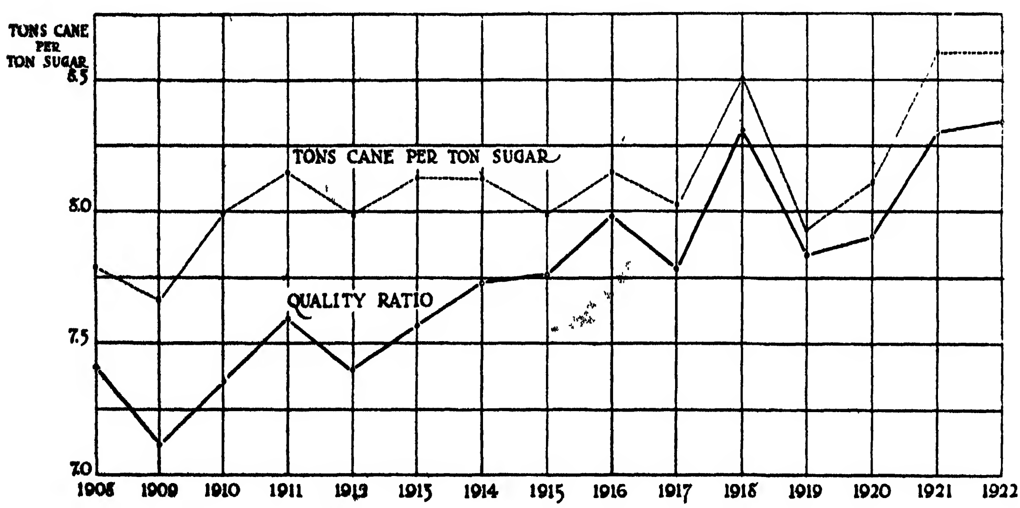


Fig. 2.

A second graph, figure 2, also prepared while studying data submitted for the Annual Synopsis, may be of interest. This is a comparison of the quality ratio with the tons of cane actually required to make a ton of sugar. It brings out the rather interesting point, that during the decade between 1910 and 1920, though the cane was constantly becoming poorer in quality, the amount of cane required to produce a ton of sugar remained practically constant, higher recoveries due to better factory work approximately offsetting the decrease in the quality of the cane. The lines converge fairly steadily up to 1919 and then diverge, indicating that the high point in factory work was reached in 1919. The decrease in the quality of the factory work since that time, however, has been slightly less than the diverging lines in the figure indicate, as it has been somewhat influenced by an increase in the polarization of the sugar. In 1921 and 1922 the polarization of the sugar was approximately 0.5 higher than in 1919. Had the sugar polarization been the same as in 1919 the distance between the two lines would be reduced by about one-fifth.

A Long Distance Shipment of Seed Cane.

Acting upon a request from the Oahu Sugar Company, on April 8, 1922, we cut and shipped to J. C. Arenberg Peeters, Koedoes, Java, twelve cuttings of seed cane of H 109. This shipment, which went forward by mail, met with undue delay at Hongkong, owing to shipping strikes, and reached Mr. Peeters on September 10, 1922. In a letter received from Mr. Peeters, he states:

> ". . . I feared the cane would be already dead, it being on the road for five months, but, to my great joy, ten from twelve cuttings proved to be still alive."

Mr. Peeters attributes the success of this shipment to the manner of packing, which was handled by Y. Kutsunai and is described as follows:

H 109 SHIPPED TO JAVA ON APRIL 8, 1922.

(1) *Seeds.* H 109 seeds were cut in Makiki field 9C, from 16 month cane. Top 6 inches were cut away and the next 2 feet were taken as seed. Healthy stick only was used as the source of seed. Each seed was inspected. Good seeds only were used. They were washed, wiped dry, and cut squarely to 15 inch length with seed cane cutter. The cut ends were paraffined immediately and labeled.

(2) *Packing Tube.* Galvanized iron tube 4 inches square and 16 inches deep with a lid overlapping 3 inches, made of 26 gage Armco iron. The tube was previously washed in water to remove acids, and dried.

(3) *Moist Charcoal Powder.* Algaroba charcoal powder passed 1/4 inch mesh was moistened with clean water at the rate of 10 pounds charcoal with 2 pounds of water.

(4) *Packing.* The tube was set upright without the lid. A handful of moist charcoal was thrown in. Four seeds were then set upright in the tube in such a way that each seed did not come in contact with other seed or the sides of the tube. All open room was filled with the moist charcoal powder as tightly as possible by jarring the tube. When the tube was entirely full, it was covered, labeled, wrapped with Manila paper, and shipped.

(5) *Gross and Net Weights.* Tube only weighed 2 lbs. 9 oz.; tube with moist charcoal, 9 lbs. 2 oz.; moist charcoal only, 6 lbs. 9 oz.

H. P. A.

Phosphoric Acid and Potash at Wailuku.

WAILUKU SUGAR COMPANY—EXPERIMENT 11 (1923 CROP)

This test was in field 37, Wailuku Sugar Co. This is one of the highest fields on the plantation, being at about 675 feet elevation. The cane was H 146, first ratoons. The stand of cane was very uneven from the beginning. This detracts somewhat from the value of the results.

All plots received nitrogen at the rate of 172 pounds per acre from 1110 pounds of nitrate of soda. In addition to this, four plots (A plots) received 375 pounds of acid phosphate per acre, equal to 60 pounds of P_2O_5. In addition to

nitrogen the four B plots were given 62.5 pounds of potash per acre from 125 pounds of sulphate of potash.

The four C plots were given both phosphoric acid and potash at the rates mentioned above.

The fertilizer was applied in two doses, in October, 1921, and March, 1922. Half the nitrogen, and all the phosphoric acid and potash were applied in October.

The experiment was harvested by the plantation. The two middle lines of each plot were weighed on field scales. The tons per acre are based on 250 lines per acre. The crusher juice samples are from carload lots.

The treatments given the different plots are tabulated as follows:

FERTILIZATION—LBS. PER ACRE

Plots	October, 1921	March, 1922	N.	P_2O_5	K_2O
X	555# N. S.	555# N. S.	172	0	0
A	555# N. S. 375# A. P.	555# N. S. 0	172	60	0
B	555# N. S. 125# S. P.	555# N. S. 0	172	0	62.5
C	555# N. S. 375# A. P. 125# S. P.	555# N. S. 0 0	172	60	62.5

Nitrate of Soda=15.5% N.
Acid Phosphate=16% P_2O_5.
Sulphate Potash=50% K_2O.

The yields were as follows:

SUMMARY OF TREATMENT AND YIELDS.

Treatment	Yield per Acre: Cane	Q. R.	Sugar
Nitrogen and phos. acid	30.8	8.05	3.83
Adjoining plots nitrogen alone	31.2	8.04	3.88
Nitrogen and potash	34.8	7.93	4.39
Adjoining plots nitrogen alone	36.6	8.04	4.55
Nitrogen, phosphate acid and potash	38.6	8.18	4.72
Adjoining plots nitrogen alone	37.5	8.04	4.67
Average all plots getting phos. acid or/and potash	34.7	8.05	4.31
Average all plots getting nitrogen only	36.0	8.04	4.48

The results show no gain from either the phosphoric acid or the potash. These results should be followed up with more experiments and soil analyses. We have but few soil samples from Wailuku and some of these are rather low in phosphoric acid.

DETAILS OF EXPERIMENT

Fertilization Test

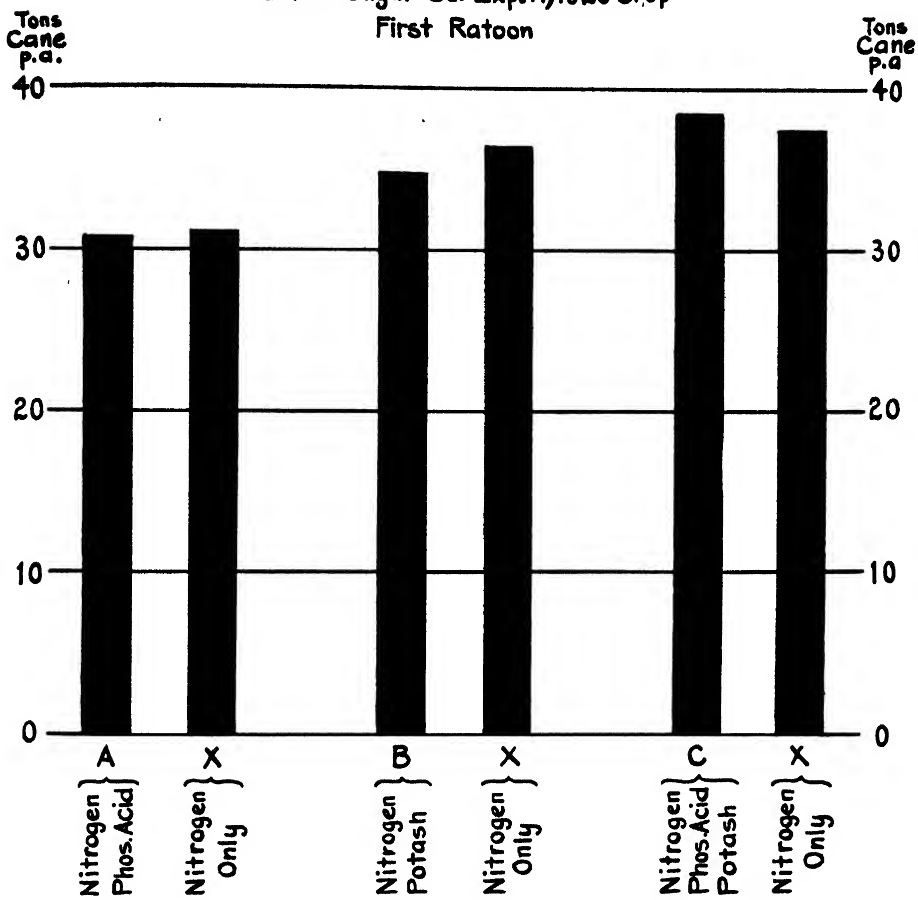
Object:

To compare nitrogen alone, with nitrogen and phos. acid, nitrogen and potash, and nitrogen, phos. acid and potash.

Plant Food Requirement

Wailuku Sugar Co. Exp. 11, 1923 Crop

First Ratoon



Summary Of Results

Plots	Treatment	Yield Per Acre		
		Cane	Q.R.	Sugar
A	Nitrogen And Phosphoric Acid.	30.8	8.05	3.83
X	Adjoining Plots Nitrogen Alone.	31.2	8.04	3 88
B	Nitrogen And Sulphate Of Potash.	34.8	7.93	4.39
X	Adjoining Plots Nitrogen Alone.	36.6	8.04	4.55
C	Nitrogen, Phos. Acid And Potash.	38.6	8.18	4.72
X	Adjoining Plots Nitrogen Alone.	37 5	8.04	4.67

Location:

Wailuku Sugar Co., Field #37, elevation 650 to 700 feet.

Crop:

H 146, 1st ratoons.

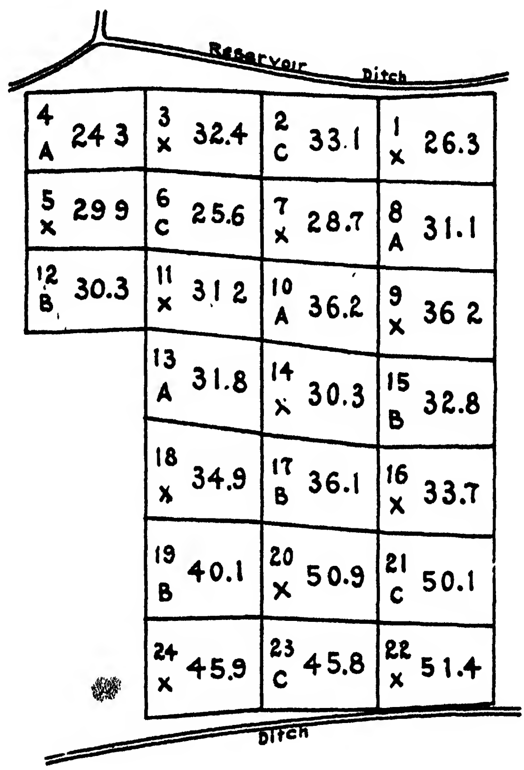
Layout:

28 plots of varying areas (approximately .025 acre). Each plot one watercourse wide.

PLANT FOOD REQUIREMENT

Wailuku Sugar Co. Exp. 11, 1923 Crop

Field 37



Plan:

Fertilizer—Pounds per Acre.

Plots	October, 1921	March, 1922
X	555# Nitrate of Soda	555# Nitrate of Soda
A	555# Nitrate of Soda	555# Nitrate of Soda
	375# Acid Phosphate	O
B	555# Nitrate of Soda	555# Nitrate of Soda
	125# Sulphate of Potash	O
C	555# Nitrate of Soda	555# Nitrate of Soda
	375# Acid Phosphate	O
	125# Sulphate of Potash	O

Field harvested by plantation January, 1923.
Juices sampled in carload lots at mill.

J. A. V.

Field Experiments at Pioneer Mill Company, 1921 and 1923 Crops.

Exp. 1—Variety Test.
Exp. 2—Amount of Fertilizer to Apply.
Exp. 3—Phosphoric Acid Test.
Exp. 4—Phosphoric Acid and Potash.
Exp. 5—Number of Applications of Fertilizer.

By J. A. Verret

These experiments are in field B 6, Kaanapali Section, Pioneer Mill Co., and are at an elevation of about 400 feet. They have now been carried on through two crops, one plant and one ratoon. Except in Experiment #1, which is a variety test, the cane is Striped Mexican. The first crop was two years old at harvest, the second eighteen months. The first crop suffered to some extent for lack of water, especially during its second year of growth.

In comparing D 1135, Striped Mexican, H 109, H 33, Lahaina and H 146, the D 1135 led in both crops by a large margin in cane and sugar. Striped Mexican was next, with H 109 third.

The profitable limit in fertilization was found to lie between 150 to 200 pounds of nitrogen per acre, depending on conditions.

Phosphoric acid was found to give increased yields. The returns from potash are somewhat doubtful. Further tests are being conducted to determine this point. Applying the fertilizer in 2, 3 or 4 doses made no essential differences in the yield of cane.

EXPERIMENT No. 1—VARIETY TEST.

In this test D 1135, Striped Mexican, H 109, H 33, Lahaina and H 146 were compared. Two crops have now been harvested. The first crop, plant, was 24½ months old when harvested in August, 1921, the second was 17½ months old at harvest in February, 1923.

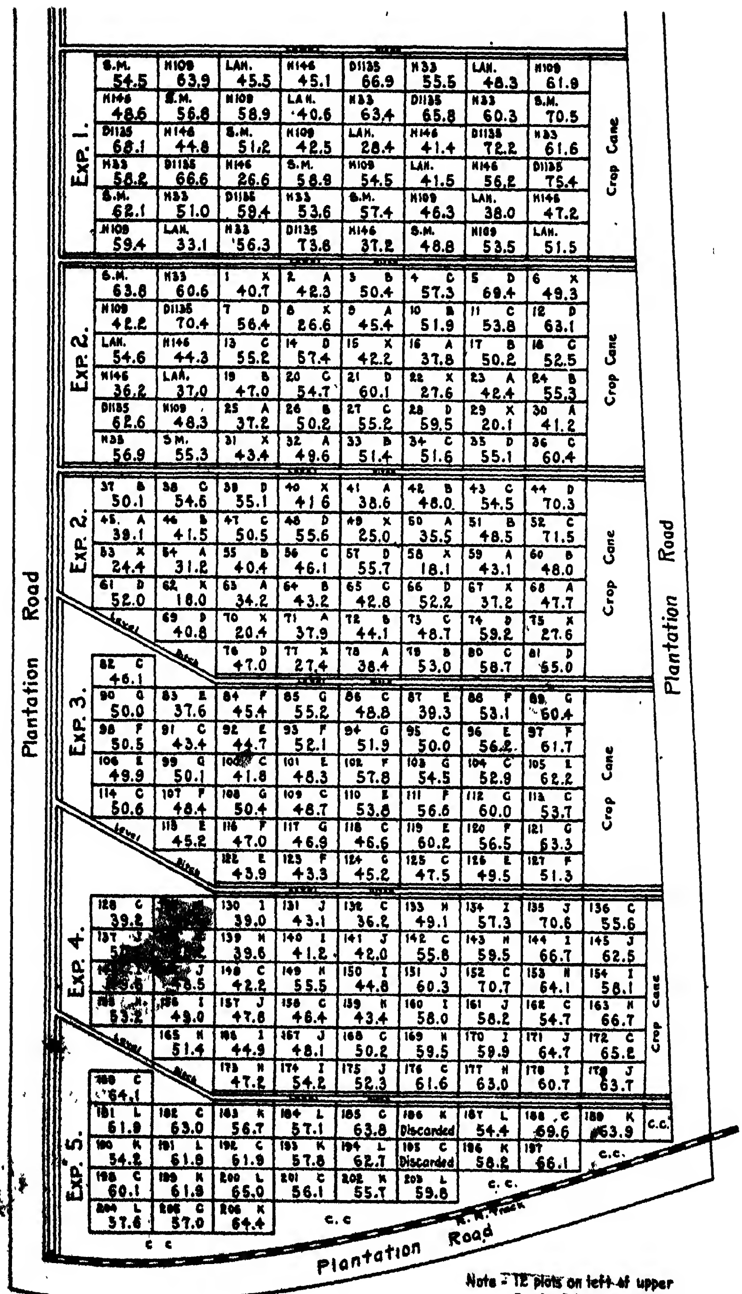
The results obtained from the two crops were as follows:

Variety	Tons Cane per Acre 1921	Tons Cane per Acre 1923	Tons Sugar per Acre 1921	Tons Sugar per Acre 1923	Total Sugar per acre in two crops
D 1135	51.5	68.1	7.44	8.98	16.42
Str. Mex.	44.2	57.9	6.16	7.75	13.91
H 109	44.6	53.1	6.60	6.91	13.51
H 33	43.3	57.7	5.64	7.42	13.06
Lahaina	41.4	41.8	6.17	5.39	11.56
H 146	30.2	42.7	4.03	5.69	9.72

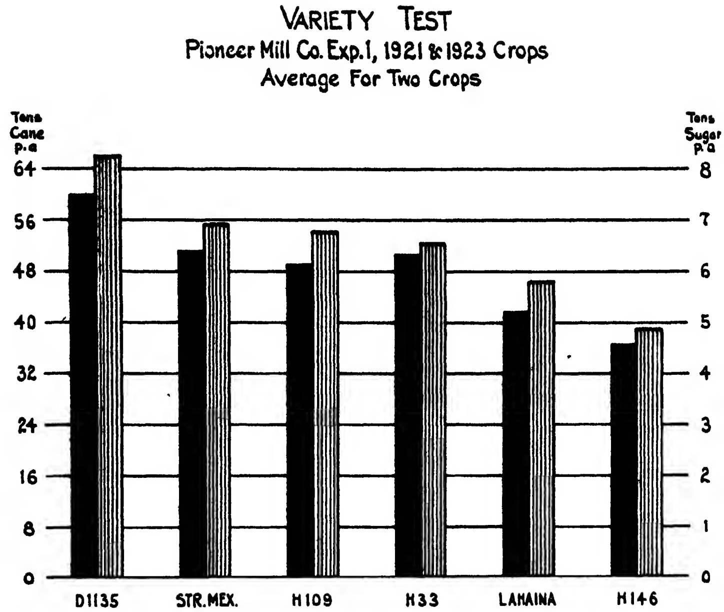
We note from the above results that the D 1135 was distinctly superior to any other variety. Not only were the cane yields heavier, but in both crops the juices were as good or better than the juices of any of the other varieties, including Lahaina.

EXP. 1. VARIETY TEST.
EXP. 2. AMOUNT OF NITROGEN TO APPLY.
EXP. 3. PHOSPHORIO ACID REQUIREMENTS.
EXP. 4. PLANT FOOD REQUIREMENTS.
EXP. 5. NUMBER OF APPLICATIONS.

Pioneer Mill Co. Expts. 1, 2, 3, 4 & 5, 1923 Crop
Field B6-L.



Note — 12 plots on left of upper Exp. 2. = Exp. 1. Others = Exp. 2.



The Lahaina and H 146 made a very poor showing and should not be planted in fields similar to one in which this test was conducted. The results obtained from H 146 are poorer than indicated by the yields. It was necessary to replant the H 146 plots rather heavily with Striped Mexican.

On the other hand, we believe D 1135 should receive more attention than it does. We hear a great deal about the difficulties in harvesting this cane, and not enough about its value as a fast ratooner, making weed control comparatively easy compared to other varieties. We do not believe that the man-days per ton of cane delivered at the mill is greater with D 1135 than with some of the other standard varieties. We know of a number of cases where it was less.

Details of Experiment.

VARIETY TEST.

Object:

To compare H 33, H 109, H 146, D 1135, Striped Mexican and Lahaina.

Location:

Pioneer Mill Co., Field B 6, Kaanapali Section.

Layout:

Number of plots, 60.

Size of plots, 1/20 acre, consisting of 7 rows two watercourses long; by measurement 31.5′ x 69.15′ from center to center of watercourse. Each row, 4.5′ x 69.15′.

Crop:

H 33, H 109, H 146, D 1135, Striped Mexican and Lahaina; 1st ratoons.

Previous crop harvested August, 1921.

Plan:

FERTILIZATION

One dose of high grade and one dose of nitrate of soda, amounting to 200 lbs. of N. and 60 lbs. of P_2O_5 per acre uniform or regular plantation practice.

Experiment harvested in Feb., 1923, by J. S. B. Pratt, Jr., helped by the plantation.

The cane was sampled in carload lots at the mill by the plantation.

EXPERIMENT No. 2—AMOUNT OF FERTILIZER

In this test varying amounts of nitrogen were compared, ranging from 0 to 250 pounds of nitrogen per acre. Half of the nitrogen was applied the first year and was from complete* fertilizer composed of 10% nitrogen, 7% P_2O_5 and 3.75% potash. Second season fertilization was from nitrate of soda.

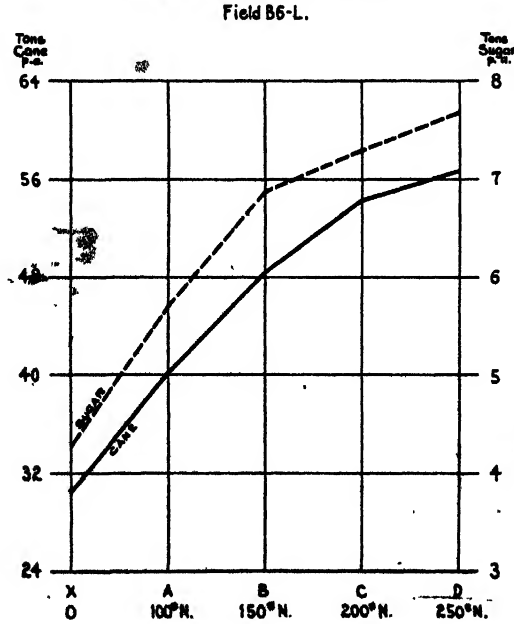
The plant cane received its fertilizer in four doses, two the first year and two the second year. The last crop got fertilizer in two doses only, one the first and one the second year. The fertilizations are tabulated as follows:

	POUNDS PER ACRE						Total
	1921 Crop				1923 Crop		Pounds
	High Grade		Nitrate Soda		High Grade	Nit. Soda	of
Plots	Oct. 1919	Nov. 1919	Feb. 1920	May 1920	Oct. 1921	Apr. 1922	Nitrogen
X	0	0	0	0	0	0	0
A	250	250	161	161	500	323	100
B	375	375	242	242	750	484	150
C	500	500	323	323	1000	645	200
D	625	625	403	403	1250	806	250

The results obtained from the two crops are tabulated as follows:

Pounds of Nitrogen per Acre	Cane per Acre 1921 Crop	Cane per Acre 1923 Crop	Sugar per Acre 1921 Crop	Sugar per Acre 1923 Crop	Total Sugar per Acre for two crops
0	42.2	30.6	6.50	4.29	10.79
100	43.5	40.1	6.58	5.71	12.29
150	48.4	48.3	7.39	6.88	14.27
200	49.2	54.2	7.22	7.30	14.52
250	49.4	56.7	7.30	7.65	14.95

AMOUNT OF NITROGEN TO APPLY
Pioneer Mill Co. Exp. 2, 1923 Crop
Field 86-L.



In this experiment we find the response to fertilization to be much greater in the ratoons than in the plant crop. This was to some extent due to water shortage in the plant crop. The economic limit in fertilization in this case is found to be from 150 to over 200 pounds of nitrogen per acre, depending upon conditions. In fields with good, deep soils, a good stand of cane, and enough water, it would seem that 200 to 250 pounds of nitrogen per acre could be used to advantage. On the other hand, if the stand of cane is poor, if the field is difficult to irrigate or the water short, 150 pounds may be the limit.

Details of Experiment.

FERTILIZATION—AMOUNT TO APPLY

Object:

To determine the economic limit of nitrogen as a fertilizer on the lands of Pioneer Mill Co. that have been cropped for many years.

Location:

Pioneer Mill Co., Field B 6.

Crop:

Striped Mexican, 1st ratoon.

Previous crop harvested August, 1921.

Layout:

No. of plots, 81.

Size of plots, 1/20 acre; each plot is 7 lines by 2 watercourses, each line being 4.5′ wide by 69.15′ long.

Plan:

Plots	No. of Plots	Pounds Fertilizer per Acre: Oct. 1921 Mixed Fert.	Pounds Fertilizer per Acre: Apr. 1922 Nit. of Soda	Total Nitrogen
X	16	0	0	0
A	16	500	323	100
B	16	750	484	150
C	16	1000	645	200
D	17	1250	806	250

Mixed Fertilizer 1st. season..10% $\begin{cases} 3\frac{1}{2} \text{ N. S.} \\ 5 \quad \text{S. A.} \\ 1\frac{1}{2} \text{ Org.} \end{cases}$

7% P_2O_5 Super

3.75% K_2O

Nitrate of Soda, 2nd. season..15.5% N.

Experiment harvested in Feb. 1923, by J. S. B. Pratt, Jr., with the help of the plantation.

Cane sampled in carload lots at the mill by the plantation.

EXPERIMENT No. 3—PHOSPHORIC ACID.

This experiment compared varying amounts of phosphoric acid, ranging from 0 to 140 pounds per acre of P_2O_5. All plots received a uniform application of nitrogen at the rate of 200 pounds per acre from nitrate of soda. The phosphoric acid was applied in one dose in October, 1921. The nitrogen was applied in two doses, October, 1921, and April, 1922.

Details of Experiment.

FERTILIZATION—PHOSPHORIC ACID AND POTASH

Object:

To determine the plant food requirements of sugar cane under conditions at Pioneer Mill Co.

Location:

Pioneer Mill Co., Field B 6.

Crop:

Striped Mexican, 1st ratoons.
Previous crop harvested August, 1921.

Layout:

No. of plots, 52.
Size of plots, 1/20 acre; each plot is 7 lines by 2 watercourses, each line being 4.5′ wide by 69.15′ long.

Plan:

Plots	No. of Plots	October, 1921 N.	October, 1921 P_2O_5	October, 1921 K_2O	April, 1922	Total lbs. per acre N.	Total lbs. per acre P_2O_5	Total lbs. per acre K_2O
C	13	100	0	0	100	200	0	0
H	13	100	100	100	100	200	100	100
I	13	100	0	100	100	200	0	100
J	13	100	0	200	100	200	0	200

N—from nitrate of soda—15.5% N.
P_2O_5—acid phosphate—16%.
K_2O—sulp. potash—50%.

Experiment harvested by J. S. B. Pratt, Jr., in February, 1923, with the help of the plantation.
Cane sampled in carload lots at mill by the plantation.

EXPERIMENT No. 5—FERTILIZER, NUMBER OF APPLICATIONS.

This was a test to determine the most profitable number of doses in which to apply a given amount of fertilizer. The number of doses varied from two to four.

The fertilizations for the two crops are given below:

1921 Crop—Pounds of Fertilizer per Acre.

Plots	Oct. 1919	Nov. 1919	Feb. 1920	May, 1920	Pounds per Acre N.	Pounds per Acre P_2O_5	Pounds per Acre K_2O
C	500# H.G.*	500# H.G.*	323# N.S.	323# N.S.	200	70	37.5
K	1000# "	0	645# "	0	200	70	37.5
L	500# "	500# H.G.*	645# "	0	200	70	37.5

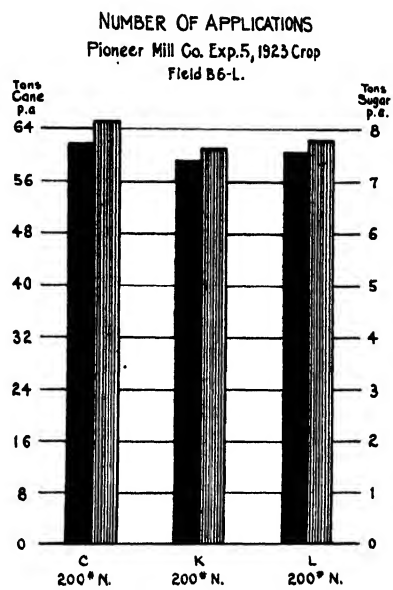
1923 Crop—Pounds of Fertilizer per Acre.

Plots	Nov. 1921	Dec. 1921	April 1922	June 1922	Pounds per Acre N.	Pounds per Acre P_2O_5	Pounds per Acre K_2O
C	500# H.G.*	500# H.G.*	323# N.S.	322# N.S.	200	70	37.5
K	1000# "	0	645# "	0	200	70	37.5
L	500# "	500# H.G.*	645# "	0	200	70	37.5

* H.G.—High Grade—10% nitrogen, 7% P_2O_5; 3.75% K_2O.

The results obtained from the two harvests are given in the following table:

No. of Doses	Tons Cane per Acre 1921 Crop	Tons Cane per Acre 1923 Crop	Tons Sugar per Acre 1921 Crop	Tons Sugar per Acre 1923 Crop	Tons Cane per Acre for two crops
Two doses	49.2	59.1	6.88	7.64	108.3
Three "	48.9	60.7	6.84	7.79	109.6
Four "	49.1	61.9	6.86	8.16	111.0



In the first crop there was no difference whatever in the yields from the different series of plots. The second crop showed slight gains in favor of the larger number of applications. The increase in cane was small, amounting to less than 3 tons per acre. The sugar increase was larger, due to apparently better juices in the "4 dose" plots. We are at a loss to explain these better juices. As a whole, our experience has been the other way, and we would have expected poorer juices from these plots. The variations in cane and sugar yields are well within experimental error.

Taking the average of all our experiments dealing with number of applications we believe that the best results are to be obtained from applying fertilizer in about 3 doses for an 18 to 24 months crop. Three doses are safer than two, and cheaper than four or more, and give about the same yields.

Details of Experiment.

FERTILIZATION—NUMBER OF APPLICATIONS.

Object:

To determine the most profitable number of applications in which a given amount of fertilizer should be applied.

Location:

Pioneer Field B 6.

Crop:

Striped Mexican—1st ratoons.

Previous crop harvested August, 1921.

Layout:

27 plots, each 1/20 acre, consisting of 7 lines by 2 watercourses. Each line 4.5′ wide, 69.15′ long. One guard row along level ditch.

Plan:

Plots	No. of Plots	Pounds of Nitrogen per Acre Nov. 1921	Dec. 1921	Apr. 1922	June 1922	Total Nitrogen per Acre
C	9	50	50	50	50	200
K	9	100	0	100	0	200
L	9	50	50	100	0	200

1st season, mixed fert.—10% N., 7% P_2O_5, 3.75% K_2O.
2nd season, nitrate of soda—15.5% N.

Experiment harvested by J. S. B. Pratt, Jr., in February, 1923, with the help of the plantation.
Cane sampled in carload lots at the mill by the plantation.

Experiments at Makee Sugar Company.

By J. A. Verret

Exp. 1, 1923 Crop

Exp. 2, 1923 Crop

Exp. 3, 1923 Crop

General.

These experiments were laid out in a comparatively low field, 100 feet or so in elevation, but in a rather wind-swept area. The cane was Yellow Caledonia; the tests were carried through three crops, one plant and two ratoon crops. The stand in the last crop, as is generally the case with second ratoons on Kauai, was somewhat irregular. This detracts to some extent from the value of the results obtained from these experiments. On the other hand, we had a rather large number of repetitions of each treatment, ranging from 8 to 14. This has a tendency to correct any irregularities which may creep in due to variations in plot yields. We, therefore, believe that the results can be accepted as fairly accurate.

In Experiment 1, where equal amounts of nitrogen from nitrate of soda, ammonium sulfate, and a mixed fertilizer were compared. the results from three crops show no essential differences in yield, indicating that the best economic policy is to supply nitrogen in its cheapest form. The mixed fertilizer contained 9% nitrogen, 7% phosphoric acid and no potash. The results obtained show that there was no response to phosphoric acid when applied at the rate of 125 pounds per acre.

In Experiment 2 we compared varying amounts of fertilizer. The results for three crops show the economic limit to be from 150 to 175 pounds of nitrogen per acre, about 1100 pounds of nitrate of soda.

In Experiment 3 we tried potash in addition to nitrogen and phosphoric acid. The results indicate some response. More work should be done with potash on this plantation.

EXPERIMENT No. 1—FORMS OF NITROGEN.

This experiment has been carried through three crops, one plant and two ratoons. The cane was Yellow Caledonia. In all cases equal amounts of nitrogen were used on all plots. The mixed fertilizer used contained 9% nitrogen, and 7% phosphoric acid. Each treatment consisted of from 8 to 10 plots, each 1/10 acre in size.

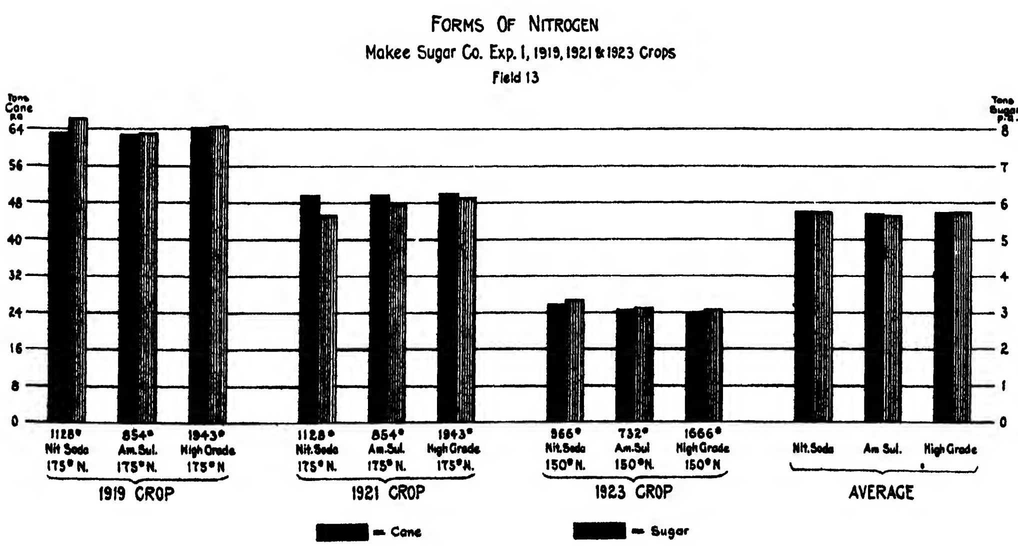
The results obtained from the three crops were as follows:

SUMMARY OF TREATMENT AND YIELDS.

Treatment	Tons Cane per Acre 1919	1921	1922	Average for 3 Crops Cane	Q. R.	Sugar
Nitrate of Soda	63.1	49.6	25.7	46.1	8.04	5.73
Ammo. Sulphate	62.7	49.8	24.5	45.7	8.07	5.66
High Grade	64.3	50.2	23.7	46.1	7.96	5.78

These results, when averaged for three crops, show no differences in favor of any special form of nitrogen. The High Grade used contained 7% phosphoric acid and was applied at the rate of 1666 pounds per acre, thereby supplying about 125 pounds of phosphoric acid.

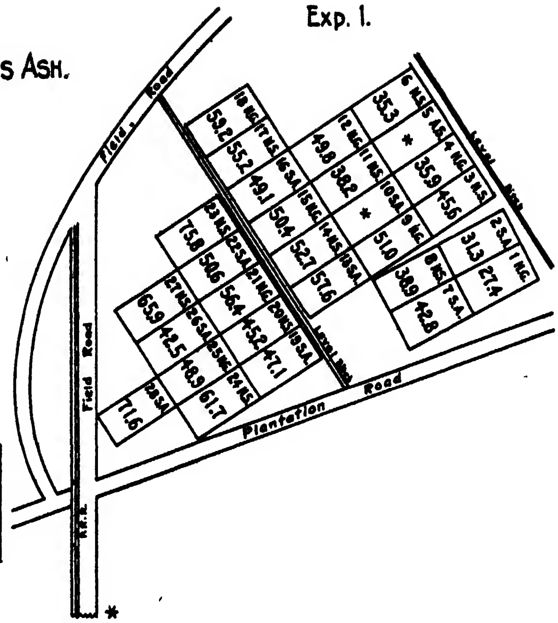
The yields from the plots receiving this phosphoric acid were not any more than were the yields from the plots getting nitrogen only. The phosphoric acid in this case was of no benefit.



Exp. 1. Forms of Nitrogen.
Exp. 2. Amount to Apply.
Exp. 3. Molasses Ash vs. No Molasses Ash.

Makee Sugar Co. Expts. 1, 2 & 3, 1923 Crop
Field 13.

Exp. 1.

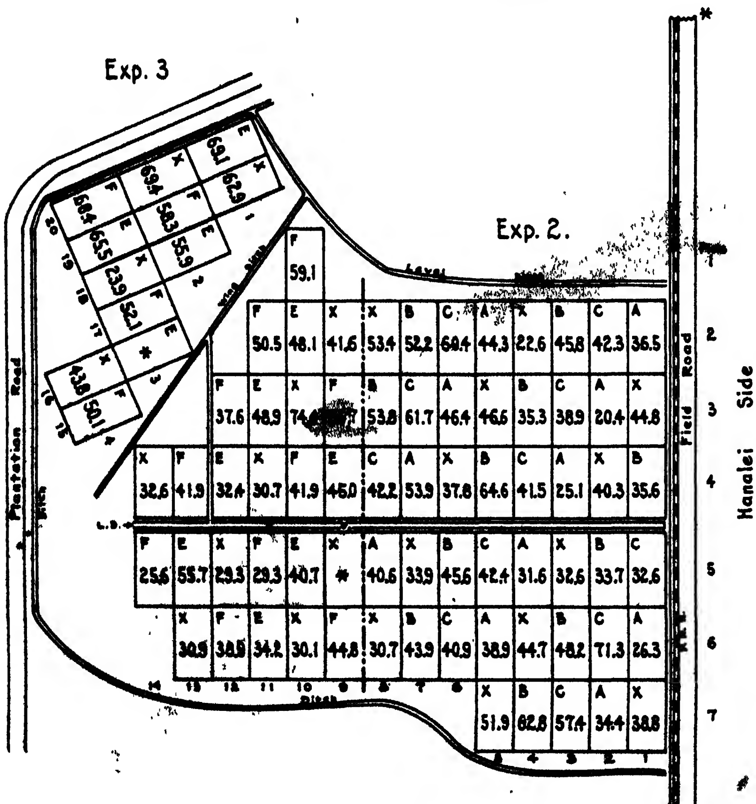


Exp. 1. Summary Of Results

Plots	No. of Plot	Treatment	Yield Per Acre Cane	Q.R.	Sugar
N.S.	10	966 lbs. Nitrate of Soda	25.7	7.74	3.32
A.S.	10	732 lbs. Ammo. Sulphate	24.5	7.88	3.31
H.G.	8	1666 lbs. High Grade	23.7	7.73	3.07

Exp. 3

Exp. 2.



Exp. 2. Summary Of Results

Plots	No. of Plot	Treatment	Yield Per Acre Cane	Q.R.	Sugar
A	11	75 lbs. Nitrogen per acre	18.1	7.82	2.31
X	12	125 lbs. Nitrogen " "	19.9	7.74	2.57
B	11	175 lbs. Nitrogen " "	23.7	7.77	3.05
C	11	225 lbs. Nitrogen " "	24.2	7.94	3.05

Exp. 3. Summary Of Results

Plots	No. of Plot	Treatment	Yield Per Acre Cane	Q.R.	Sugar
X	12	No Molasses Ash	21.3	8.30	2.57
E	11	300# Molasses Ash	24.8	8.31	2.98
F	14	600# Molasses Ash	23.4	8.24	2.84

Details of Experiment.

FORMS OF NITROGEN

Object:

To compare the results from equal amounts of nitrogen obtained from nitrate of soda, sulfate ammonia, and a high grade fertilizer containing the nitrogen in sulfate, nitrate and organic forms.

Location:

Field 13.

Crop:

Yellow Caledonia, second ratoons.

Layout:

No. of plots, 28. Size of plots, 1/10 acre, 90′ by 48.4′, consisting of 20 straight lines, each 48.4′ by 4.5′.

Plan:

Plots	No. of Plots	Fertilizer	Aug. 1921	Feb. 1922	Total N.
NS	10	Nit. Soda	483	483	150
SA	10	Ammo. Sulf.	366	366	150
HG	8	High Grade	833	833	150

Nitrate of Soda—15.5% Nitrogen.

Sulfate of Ammonia—20.5% Nitrogen.

High Grade—9% Nitrogen (3% Nit. Soda, 3% sul. of amm., 3% organic) 7% P_2O_5 (4% acid phos., 3% bonemeal).

Experiment harvested January, 1922, by O. C. Markwell.

Juices sampled in carload lots at mill by the plantation.

EXPERIMENT No. 2—AMOUNT OF NITROGEN.

In this experiment varying amounts of nitrogen were used, ranging from 75 to 300 pounds per acre for the first two crops and from 75 to 225 pounds for the last crop. Half of the nitrogen used was from high grade fertilizer containing 9% nitrogen and 7% phosphoric acid. This was applied during the first season. The remaining nitrogen applied during the second season was from nitrate of soda.

The cane was Yellow Caledonia. Each treatment was repeated 11 or 12 times on 1/10 acre plots, there being 45 plots in the experiment.

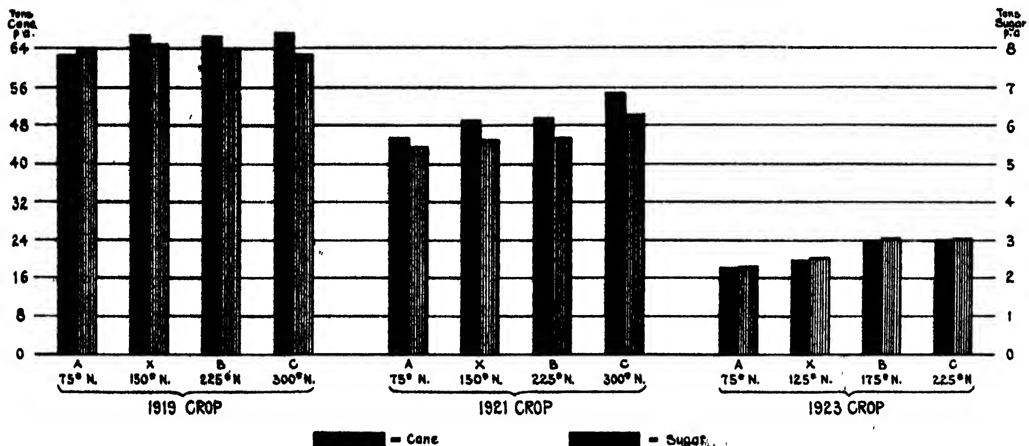
The sugar per acre for the first two crops was as follows:

Treatment		Total Pounds Nitrogen	Sugar per Acre		
High Grade	Nit. Soda		1919	1921	Average
416 Lbs. p. a.	242 Lbs. p. a.	75	8.03	5.44	6.73
832 " "	484 " "	150	8.14	5.65	6.89
1250 " "	726 " "	225	8.01	5.68	6.84
1666 " "	968 " "	300	7.87	6.28	7.07

The results of the last crop are given as follows:

Treatment		Total Pounds Nitrogen	Yield per Acre		
High Grade	Nit. Soda		Cane	Q.R.	Sugar
416 Lbs. p. a.	242 Lbs. p. a.	75	18.1	7.82	2.31
694 " "	403 " "	125	19.9	7.74	2.57
972 " "	564 " "	175	23.7	7.77	3.05
1250 " "	725 " "	225	24.2	7.94	3.05

AMOUNT OF NITROGEN TO APPLY
Makee Sugar Co. Exp. 2, 1919, 1921 & 1923 Crops
Field 13.



Under the conditions of this experiment the profitable limit of nitrogen application is found to be from 150 to 175 pounds per acre. This would be furnished by, say, 900 pounds of high grade and 550 pounds of nitrate of soda or 1100 pounds of nitrate of soda without high grade. These amounts to be raised or lowered according to good or bad conditions with regard to water, stand of cane, etc.

Details of Experiment.

FERTILIZER EXPERIMENT—AMOUNT TO APPLY

Object:

To determine the most profitable amount of nitrogen to apply at Makee Plantation, 75, 125, 175 or 225 lbs.

Location:

Field 13.

Crop:

Yellow Caledonia, second ratoons.

Plots:

No. of plots, 45. Size of plots, 1/10th acre, 48.4′ x 90′, consisting of 20 straight lines, each 48.4′ x 4.5′.

Plan:

Fertilization in pounds of nitrogen per acre and in pounds fertilizer.

Plots	No. of Plots	August, 1921 # High Grade	March, 1922 # Nit. Soda	Total N.
A	11	416	242	75
X	12	694	403	125
B	11	972	564	175
C	11	1250	725	225

The high grade fertilizer applied in August to have following analysis: 9% nitrogen (3% N. S., 3% Sulfate of Ammonia, 3% Organic) 7% P_2O_5 (4% water soluble, 3% Bonemeal).

Nitrate of soda applied March, 1922, to have 15.5% Nitrogen.

Experiment harvested in January, 1922, by O. C. Markwell.

Juices sampled in carload lots by the plantation.

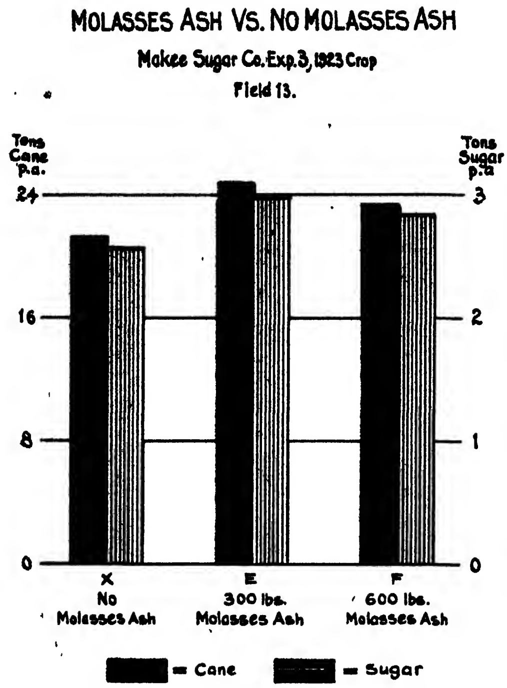
EXPERIMENT No. 3—POTASH FROM MOLASSES ASH.

In this experiment we tried to determine the need of the soil for potash. Molasses ash containing 20% K_2O was applied at the rate of 300 and 600 pounds per acre. The experiment consisted of a total of 37 plots, each 1/10 acre in size. Twelve of these plots did not get any potash, 11 got molasses ash at the rate of 300 pounds per acre and 14 at the rate of 600 pounds. All plots received nitrogen at the rate of 150 pounds per acre from nitrate of soda.

The yields obtained are tabulated as follows:

Treatment	Pounds Potash p. a.	Yield per Acre Cane	Q. R.	Sugar
No molasses ash	0	21.3	8.30	2.57
300 lbs. molasses ash	60	24.8	8.31	2.98
600 " " "	120	23.4	8.24	2.84

The results here show a response to potash amounting to about 1/3 of a ton of sugar per acre. It is not safe to form conclusions from the results of one experiment, but the indications are that potash rather than phosphoric acid should be used in the high grade applied to all fields similar to the one where the tests were conducted.



Details of Experiment.

FERTILIZER EXPERIMENT—VALUE OF POTASH

Object:

To determine the value of potash in molasses ash on Makee land.

Location:

Field 13.

Crop:

Yellow Caledonia, second ratoons.

Layout:

No. of plots, 37. Size of plots, 1/10th acre, 90′ x 48.4′. All plots have 20 straight lines 48.4′ x 4.5′ except plots 10.4, 10.5, 10.6, 11.4, 11.5, 11.6, 12.4, 12.5, 12.6, 13.4, 13.5, 13.6, 14.4, and 14.5.

Plan:

Plots	No. of Plots	Amount of Molasses Ash
X	12	0
E	11	200#
F	14	400#

150 pounds of nitrogen per acre, from nitrate of soda, applied uniformally to all plots.
Experiment harvested in January, 1923, by O. C. Markwell.
Juices sampled from carload lots at mill by plantation.

Reliability of Optical Sucrose Determination.

By W. R. McAllep and H. F. Bomonti.

During the present clarification investigation the reliability of determination of sucrose in cane juices by the double polarization method was studied by comparing them with sucrose determinations made by a chemical method. Attention was directed to this subject by the increase in purity from clarified juice to syrup at a number of factories after adopting a more alkaline clarification. Such an increase in apparent purity is in part due to the change in the ratio of polarization to sucrose, caused by the action of alkalies at high temperatures on the non-sucrose constituents of the juice. Increases in gravity purity, however, have also been found and these comparisons were made to see if a change in the ratio of optical sucrose determinations, similar to the change in the ratio of polarization, to the actual sucrose content could be detected. Such a change should be shown by comparisons with chemical determinations, as the two methods are based on entirely different principles and it is hardly probable that a factor that might cause an error in one of them would affect the other in the same way.

An excellent opportunity for this study came about when we were working on clarified juices, digesting them at high temperatures. The samples covered a somewhat wider range of acidity and alkalinity than is encountered in ordinary factory practice, and they were from mixed juices varying from .5 to 1.5 per cent glucose.

Optical determinations were made according to the Hawaiian Chemists' Association Methods with Walker's method of inversion. Chemical determinations were based on the reduction of copper, glucose being first determined in the original juice, then glucose plus invert sugar in the juice after inversion. After subtracting the original glucose from glucose plus the invert sugar, the latter was calculated to sucrose. Details of the chemical method follow:

Glucose. Weigh a calculated amount (usually 30 to 35 grams) of juice into a 100 cc. flask, add 1 cc. of neutral lead acetate and 2.5 cc. of 10% disodium phosphate. Make up to 100 cc. and filter. Take a quantity of this filtrate containing 2 grams of total sugars (sucrose plus glucose) in a 400 cc. beaker, add water to a volume of 50 cc. and determine glucose following Munson and Walker's method. For convenience the quantity of juice taken should be such that 50 cc. of the filtrate contains 2 grams of total sugars.

Sucrose. Weigh out 35 to 45 cc. of juice, transfer to a 500 cc. flask using sufficient water to bring the volume to 75 cc. Add 1 or 2 cc. of 6 N hydrochloric acid, heat in a water bath to between 65 to 67° C., add 10 cc. 6 N hydrochloric acid, let stand for one half hour, cool and neutralize with 6 N sodium hydrate. Add 1 cc. neutral lead acetate, 3 cc. 10% disodium phosphate, make up to 500 cc. and filter, adding some dry kieselguhr if necessary to secure a clear filtrate. Take a portion of the filtrate containing approximately, but not more than, 230 milligrams of glucose in a 400 cc. beaker, add water to bring the volume to 50 cc. and determine invert sugar by Munson and Walker's method. From the percent of invert sugar so found subtract the glucose found before inversion and calculate the invert sugar to sucrose, multiplying by the factor .95.

The sample analyzed is small, usually corresponding to somewhat less than 2 grams of the original juice and the greatest care must be taken with details of the manipulation. An error of one milligram in determining the amount of copper reduced, corresponding to approximately half a milligram of invert sugar,

introduces an error of .03 in the sucrose determination. Weighing as cupric oxide did not give sufficiently consistent results so the amount of copper reduced was determined by the following method:

Thiosulphate method. **Place the Gooch crucible containing the reduced copper in a 250 cc. beaker with 5 to 10 cc. of nitric acid*, let stand 15 to 30 minutes and filter into a 300 cc. Erlenmeyer flask, washing the crucible and mat thoroughly with hot water. Evaporate on a hot plate to 50 cc., add 1.5 grams of washed neutral talcum powder and boil 5 to 10 minutes longer. Cool, add 2 cc. of concentrated sulphuric acid and 10 cc. of a saturated solution of potassium iodide. Titrate with a sodium thiosulphate solution standardized against pure copper. A convenient strength is 1/5 normal. The end point is sharp and titration should be made to .1 or if possible .05 cc. The thiosulphate solution used in this work was the equivalent of 13.14 milligrams of copper per cc.**

Sucrose was determined by both optical and chemical methods before and after digestion, in the juices of four of the digestion experiments. Experiments 2 and 8 were clarification series in which portions of mixed juice were limed to different reactions, boiled, filtered with kieselguhr and digested at 180° F. Experiment 13 was a single portion of juice clarified in the same way but digested at 200°. 16 was the same as 13, except that the digestion temperature was 212. The time of digestion in all cases was 22 hours. The analyses are arranged in table 1, light faced figures being analyses before and dark faced figures analyses after digestion.

Before examining the data further, we will touch briefly on the behavior of the juice during digestion and the limits of accuracy in the methods employed. Clarified juices change in reaction when held at high temperatures, becoming more acid. Of the juices, the analyses of which are shown in table 1, three reached neutrality or acidity to litmus, the rest remaining alkaline to this indicator. Even though most of them did not become actually acid to litmus, their reaction was sufficiently acid so that inversion of sucrose, indicated by a distinct increase in the glucose content, took place in all with the exceptions of juices 4 and 5 in Experiment 2, and possibly 3 in Experiment 8.

With respect to the accuracy of the determinations, the actual inversion, which was formerly the greatest source of inaccuracy in such methods, can probably be accomplished with close to absolute accuracy with the Walker method. Both the optical and chemical methods, however, require several manipulations and measurements, none of which are of absolute accuracy, particularly in the absence of elaborate equipment for temperature control. A study of the probable effect of these inaccuracies indicated .05 as a reasonable limit of error in a single determination and .1 in a comparison involving two determinations, one by each method. The latter figure corresponds to a difference of some .7 in purity. As this is large in proportion to any probable size of the factor we are studying, conclusions cannot be drawn from individual determinations, but must be based on averages.

*** One part of concentrated acid to two parts of water.**

TABLE I.—OPTICAL AND CHEMICAL SUCROSE DETERMINATIONS.
Light faced figures are the analyses before and heavy faced figures the analyses after digestion.

	Brix	Glucose	Sucrose — Optical	Sucrose — Chemical	Reaction* — Litmus	Reaction* — Phenol-phthalein	PH
Experiment 2—Before and After Digesting 22 Hours at 180° F.							
Filtered mixed juice ...	13.54	0.63	11.50	11.51	.010	.062	5.73
#1 Clarified–2.5 cc. lime	14.01	0.68	11.80	11.79	.004	.042	6.24
	13.97	**1.08**	**11.48**	**11.41**	**.008**	**.051**	**5.99**
#2 Clarified–5 cc. lime	13.75	0.67	11.80	11.80	.003	.032	6.78
	13.82	**0.76**	**11.75**	**11.69**	**.002**	**.031**	**6.41**
#3 Clarified–7.5 cc. lime	13.60	0.64	11.71	11.69	.008	.016	8.18
	13.62	**0.68**	**11.76**	**11.75**	**.003**	**.016**	**6.86**
#4 Clarified–10 cc. lime	13.71	0.63	11.84	11.81	.011	.002	8.55
	14.00	**0.64**	**12.12**	**12.05**	**.005**	**.012**	**7.25**
#5 Clarified–12.5cc. lime	13.64	0.59	11.87	11.87	.014	.002	8.69
	13.77	**0.60**	**11.99**	**11.95**	**.012**	**.008**	**7.34**
Experiment 8—Before and After Digesting 22 Hours at 180° F.							
Filtered mixed juice...	13.65	0.58	11.85	11.91	.010	.050	5.73
#1 Clarified–5 cc. lime	13.71	0.62	12.05	12.04	.006	.020	6.91
	13.80	**0.72**	**11.97**	**11.97**	**.001**	**.025**	**6.58**
#2 Clarified–7.5 cc. lime	13.82	0.60	12.16	12.20	.008	.008	7.60
	13.89	**0.63**	**12.17**	**12.22**	**.002**	**.013**	**7.01**
#3 Clarified–10 cc. lime	13.92	0.59	12.32	12.31	.010	.004	8.27
	13.97	**0.60**	**12.29**	**12.34**	**.004**	**.008**	**7.42**
#4 Clarified–12.5cc. lime	13.83	0.54	12.21	12.27	.011	.002	....
	13.92	**0.59**	**12.19**	**12.23**	**.005**	**.007**	**7.34**
#5 Clarified–15 cc. lime	13.76	0.51	12.21	12.18	.012	.001	....
	13.81	**0.57**	**12.20**	**12.24**	**.005**	**.001**	**7.42**
Experiment 13—Before and After Digesting 22 Hours at 200° F.							
Clarified juice	15.10	0.25	13.97	13.98	.012	.002	8.57
	15.11	0.75	13.25	13.51	.0	.009	6.85
Experiment 16—Before and After Heating 22 Hours at 212° F.							
Clarified juice	13.28	1.60	10.63	10.61	.018	.002	8.8
	13.33	**4.26**	**8.01**	**8.04**	**.018**	**.020**	**5.22**
Average			11.90	11.90			

* Underlined figures indicate acidity.

Table 2 is an analysis of the figures in table 1. The first, second and third columns are respectively the difference between optical and chemical determinations on mixed juice, clarified juice and clarified juice after digestion. The fourth column shows the change in the relation of the optical to the chemical sucrose during clarification, and column five shows the change during digestion. A plus sign in the first three columns indicates that the optical was greater than the chemical determination, and a plus sign in the fourth and fifth column indicates that the optical determination increased in proportion to the chemical during clarification and digestion respectively.

TABLE II.—DIFFERENCES BETWEEN OPTICAL AND CHEMICAL SUCROSE DETERMINATION

Plus signs in the first, second and third columns indicate that the optical exceeded the chemical determination and in the fourth and fifth columns that the optical determination increased in proportion to the chemical.

		Before Clarification	After Clarification	After Digestion	Change during Clarification	Change during Digestion
Experiment #2	Juice #1	—	+.01	+.07	—	+.06
22 Hours at 180 F.	" #2	—	0	+.06	—	+.06
	" #3	—	+.02	+.01	—	—.01
	" #4	—	+.03	+.07	—	+.04
	" #5	—	0	+.04	—	+.04
	Average	—.01	+.01	+.05	+.02	+.04
Experiment #8	Juice #1	—	+.01	0	—	—.01
22 Hours at 180 F.	" #2	—	—.04	—.05	—	—.01
	" #3	—	+.01	—.05	—	—.06
	" #4	—	—.06	—.04	—	+.02
	" #5	—	+.03	—.04	—	—.07
	Average	—.06	—.01	—.04	+.05	—.03
Experiment 13, 22 Hours at 200 F.		—	—.01	+.01	—	+.02
Experiment 16, 22 Hours at 212 F.		—	+.02	—.03	—	—.05
	Averages	—.03	+.002	+.004	+.03	+.002

The maximum difference shown in the first three columns of table 2 is .07, corresponding to .5 in purity; a figure smaller than the estimated probable error, but still large enough to prevent drawing conclusions from individual comparisons. The maximum change during clarification or digestion (columns 4 and 5) also does not exceed the estimated limit of error.

If digesting alkaline juices at high temperatures causes an increase in the optical sucrose determinations in comparison with the actual sucrose content, assuming for purposes of comparison that the chemical determination represents the actual sucrose, plus values will be found in the fifth column. There should also be a tendency for the more alkaline juices in Experiments 2 and 8 to show the greater plus values. The average of the fifth column is indeed a positive value, plus .002, corresponding to between .01 and .02 purity. This is small enough to be considered negligible. The figures in the second and fifth column show no pronounced tendency toward greater plus values in the more alkaline juices. We may then conclude that any error in the optical sucrose determination caused by

the alkaline digestion is too small to be detected by the methods employed and that it may be considered negligible.

Data secured during the digestion experiments throw further light on the reliability of the optical sucrose determinations. Analyses of 63 juices, including sucrose and glucose determinations before and after digestion, are available. In one sample only was there any indication of destruction of glucose and in this case the amount did not exceed reasonable limits of error. With no destruction of glucose, the total sugars before and after digestion should be in agreement if the accuracy of the analyses is not affected by the digestion. Averages of these analyses follow. The figures in the last column are the analyses after digestion calculated back to the density of the juice before digestion.

	Before Digestion	After Digestion	After digestion Corrected for evaporation
Brix	14.517	14.540	14.517
Sucrose	12.695	12.575	12.555
Glucose	.641	.785	.784

Total sugars after digestion, corrected for evaporation, are 13.339. This includes .143 invert sugar formed during digestion, from which 5% must be deducted to calculate it back to the original sucrose. Subtracting this 5%, amounting to .007 from 13.339, we have 13.332 total sugars after digestion against 13.336 before digestion. The difference .004, corresponding to .03 in purity, is negligible. It is, however, in the opposite direction to the small difference that was found in the comparisons with chemical sucrose determinations.

Both the optical and chemical methods will give the true sucrose content in a pure solution for it is on this that they are based. It is possible, however, that impurities can cause an error in either, but that such entirely different characteristics, as the rotation of a ray of polarized light and the reduction of copper, should be affected to the same extent and in the same way is quite improbable. The averages of all the determinations, shown in table 1, are identical. While there is a possibility of compensating errors, the close agreement strongly indicates that the results found coincide closely with the true sucrose content.

The possibility that clarification might cause a change in the optical determination has not been thoroughly studied, as other work has so far prevented investigation of this subject. Chemical determinations were made on the mixed juices in experiments 2 and 8. The differences before and after clarification are arranged in columns 1, 2 and 4 of table 2, in a similar manner to the differences before and after digestion in the same table. Though two determinations are not sufficient data on which to base conclusions, taking the figures as they stand, we find a plus difference in column four of .03. Again assuming the chemical determination to correspond with the correct sucrose content this would indicate an apparent increase in purity of .2, due to error in the optical determination. If, however, such an error actually exists it should be more pronounced in the more alkaline members of a clarification series. On the whole, figures in the second column do not give a definite indication that this is the case, rendering it somewhat improbable that the error actually exists. Unfortunately, comparison cannot be made of the total sugars before and after clarification as was done before and after digestion, for the available analyses cannot be corrected for evaporation during clarification. The error, if it actually exists, is small, probably not affecting the gravity purity more than two or three tenths.

While this work was not carried to the point where we can state positively that no change in optical sucrose determinations is caused by clarification, it does give us definite information as to the reliability of optical determination when clarified juices are further heated. As no material change in the relation of the optical to chemical sucrose determinations has been found, and as the total sugars before and after digestion are in close agreement, we can conclude that in clarified juices, limed within the limits practicable in factory work, digestion at high temperatures does not cause an error in optical sucrose determinations, and further, the fact that the two methods have given identical results strongly indicates that the optical method gives the actual sucrose content of the juice. A corollary to these conclusions is that increases in gravity purity from clarified juice to syrup are not to be attributed to errors in the method of analysis.

Preparation of Cane Fibre Samples*

By John P. Frank

The influence of the fiber content of the cane on all the other control figures is well understood. The importance of closer observation of the analysis of this constituent, the method of sampling the cane ground, and the procedure in preparing the cane samples lead the writer to conduct experiments along these lines.

Each day two parcels of cane were selected as samples and labelled A and B. Each parcel was subsampled as directed in hand book of "Methods of Chemical Control" and two analyses were made on each parcel, one prepared with a disintegrator, and the other prepared with a Japanese plane. All samples received the same amount of washing, pressing and drying. The following are the results obtained. (Figures on the same line represent the same parcel of cane):

RESULTS OF FIBER ANALYSES

	Disintegrated Sample	Planed Sample	Difference
June 14.	13.25	13.00	
	11.85	11.35	.38
15.	13.00	11.40	
	11.20	11.10	.95
16.	12.50	12.60	
	13.85	13.50	.12
21.	13.35	12.30	
	13.50	12.20	1.17
22.	13.95	12.05	
	13.45	12.25	1.53
23.	13.60	12.60	
	14.45	12.05	1.70
24.	13.50	11.95	
	12.10	10.95	1.35
26.	13.65	12.85	
	13.40	12.50	.85
27.	12.05	10.90	
	13.65	13.10	.85

*Presented at first annual meeting of the Association of Hawaiian Sugar Technologists, Honolulu, November 15-18, 1922.

RESULTS OF FIBER ANALYSES (Continued)

	Disintegrated Sample	Planed Sample	Difference
June 29.	11.10	12.90	
	13.40	12.25	.22
30.	12.85	12.35	
	14.40	14.20	.35
July 1.	12.75	12.10	
	12.85	11.60	.95
6.	12.75	10.20	
	12.80	12.25	1.55
7.	12.95	12.50	
	14.20	11.95	1.35
10.	12.30	11.75	
	11.65	11.85	.17
11.	12.50	11.55	
	12.20	11.55	.80
Total Av.	12.97	12.11	
Plus	0.70 for fiber in trash	0.70	
	13.67% fiber in cane	12.81%	.86

The above figures given by the two methods differ by 0.86. As the cane was of the same quality in both cases, the question would naturally follow, "Why the difference?"

The writer found that cane samples, after passing through the disintegrator, were divided into two portions, one long and stringy and the other derived from the pith in a fine mealy state of division. On mixing such a sample, it was found that a large portion of the fine mealy particles sift through the long stringy fibrous portion and settle on the bottom.

A number of experiments conducted by Noel Deerr, indicate that the fiber content of the pith of the cane is one third of the fiber contained in the rind and nodes. In the writer's analyses on disintegrated cane, the samples weighed for analysis were not representative, but without doubt, on account of the tendency of the mealy particles of pith fiber to sift to the bottom, contained too great a proportion of the long, stringy node and rind fiber.

It is not the writer's intention to suggest a particular make of machine for the purposes of disintegration or preparation of the cane fiber sample, but a desire to call the attention of those interested to the fact that, in this particular step in the fiber determination, the chance of introducing errors is great.

In conclusion, the writer maintains that the sample should be in a uniform state of division. If a disintegrated sample is not of a uniform state of division, the subsample weighed out for analysis will not, in the majority of cases, be representative of the original sample.

A Description of the Air Lift Pump*

By George Duncan

An air lift pump installation which has been completed at Olaa may be of some interest.

This installation consists of two air lift pumps, which replaced two plunger pumps of about 200,000 gallons per 24 hours each. The two wells were drilled in 1904 for supplying the mill with water for condenser purposes. Previous to this time it depended absolutely upon the cane flumes for its water supply. This was rather an uncertain factor, and at times failed entirely.

In 1904 arrangements were made to drill two 12″ wells, 240 feet deep, and install two 8″ single acting deep well plunger pumps. The elevation of the mill is 220 feet above sea level. Water was struck at 203 feet below the ground level, this then gave 37 feet of standing water when drilling was discontinued.

As these pumps gave considerable trouble, especially at the time they were most urgently needed and as the requirements of the mill increased from year to year, means had to be devised whereby the water supply might be increased. The scarcity of water was further augmented when a paper mill was installed in 1919.

We were certain there was an abundance of water at or near sea level, because from an average yearly rainfall of 200″ there is practically no surface drainage in the territory extending from Hilo to Kau. This is due to the porous condition of the soil which is of comparatively recent volcanic origin. Also all along the coast large quantities of fresh water pour into the sea all the year round. From this we were justified in deciding upon the air lift pump as the most economical means for getting this additional water supply.

For the benefit of the few who may not know the basic principles of the air lift pump it might be well to give a brief description of this system of pumping.

Description

Pumping water by means of the air lift system is not a new invention or idea and hundreds of installations are to be found scattered throughout different parts of the world.

Very little seems to have been written on this subject and it is hard to get hold of any formulas and tables for making the proper calculations in connection with the different installations. Manufacturers of these air lift pumps must have collected a vast amount of data from their own private experiments and from the results of the systems they have installed. Yet there seems to be a reluctance on their part to give out these formulas.

One of the best articles on this subject I have seen so far is "The Air Lift," by Prof. A. H. Blaisdell, Pittsburgh, in "Power," November 23rd, 1920. All of the formulas given here are taken from this article with the exception of the efficiency formula which does not appear in the article but is by the same author.

The standard terms used in air lift work together with the definition of same is herewith given:

* Presented at first annual meeting of the Association of Hawaiian Sugar Technologists, Honolulu, November 15-18, 1922.

Static Head:

Normal water level when not pumping.

Drop:

Point to which the water level drops while being pumped.

Pumping Head:

Level of water when pumping as compared to ground surface.

Static Head + Drop = Pumping Head.

Elevation:

Point above the ground surface to which water is being raised.

Lift:

Distance water is elevated from level when pumping, to point of discharge and includes Elevation + Static Head + Drop = Lift.

Submergence:

Depth of the air pipe below the pumping head.

Starting Submergence:

Depth of the air pipe below the Static Head.

Drop + Submergence = Starting Submergence.

100 Per Cent:

The vertical distance the air travels with the water from point of introduction to point of discharge.

Figure 1 shows this in diagramtic form.

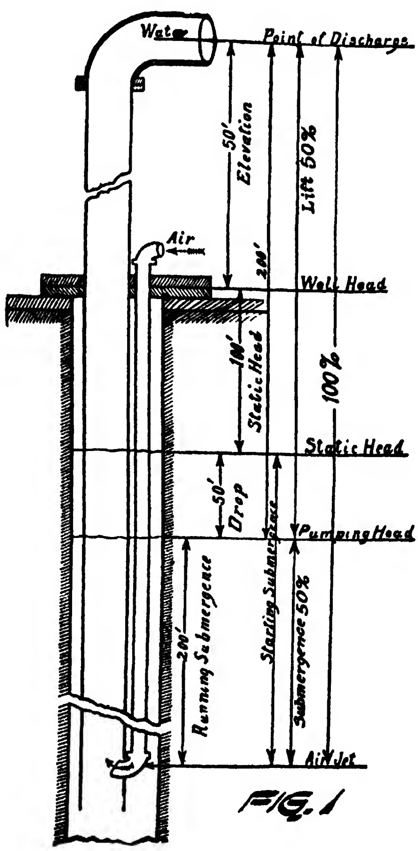


FIG. 1

In its simplest form the air lift pump consists of a pipe submerged in a column of water and a smaller pipe delivering air into it at the bottom. The theory is that if the water inside the pipe is to be induced to rise higher than the water on the outside, means must be devised to lower the specific gravity of the column of water as a whole contained within the pipe. Then the greater relative weight of water on the outside would tend to force the lighter column upwards.

What could be simpler for this purpose than the introduction of air?

In order to obtain a fair degree of efficiency, means must be devised to have a thorough mixture of the air and water. If the air is introduced in a haphazard way it has a tendency to form into large bubbles which drive through the water without doing their useful share of work. The slip of the bubbles constitutes the chief loss of energy. This varies as the square root of the volume of the bubbles. It is therefore desirable to reduce the size of them by any possible means.

In 1886 when Dr. J. G. Pohle obtained U. S. patents involving this system, he worked on the theory of alternate plugs of air and water, with the pipes submerged 60%. The highest efficiency he obtained was from 20 to 25%. Since that time improved methods of construction have more than doubled this figure. This has involved the thorough and continuous mixing of the air and water, proper proportioning of the discharge or eduction pipe and giving the installation the proper amount of submergence; all of these facts having been obtained by costly experiments.

Figure 2 shows the original Pohle or Side inlet pump or foot-piece, while Figure 3 is the Pohle annular foot-piece. In this foot-piece the air fills the annular space surrounding the eduction pipe and is free to enter the rising column

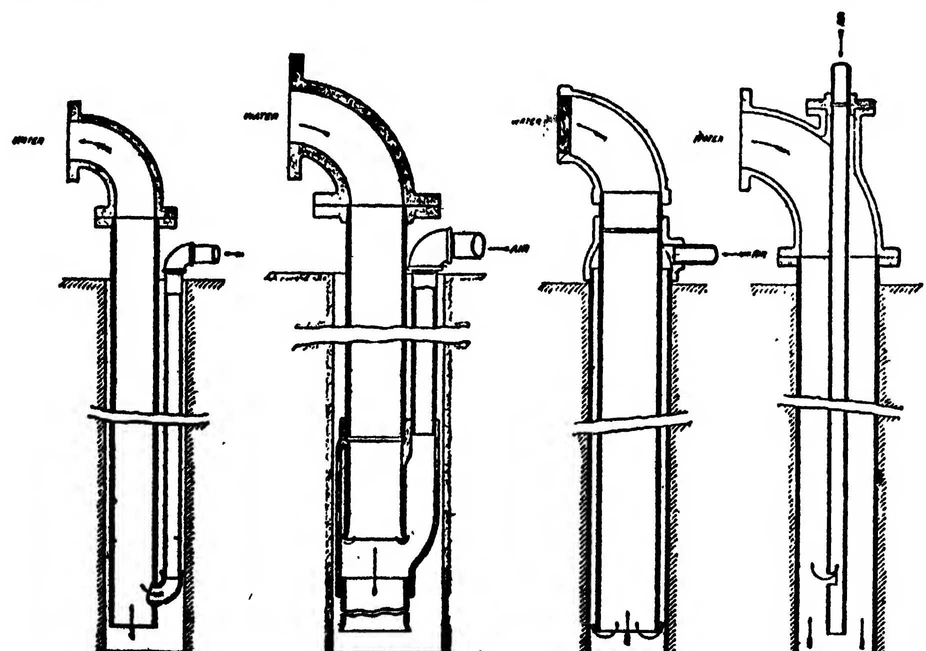


FIG. 2 FIG. 3 FIG. 4 FIG. 5

at all points of its periphery, at the same time acting without obstructing or contracting the discharge pipe anywhere.

Figure 4 shows the Saunders or Reservoir system. In this system the well has to be cased all the way down and a little past the point where the air enters the eduction pipe. It is used in wells which will not permit the use of the side inlet on account of lack of space.

Figure 5 shows the Central Pipe system which is just the reverse of the arrangement described.

In none of these systems has there been any attempt made to mix the air and water thoroughly, with the result that the efficiency has been low, owing to the discharge being a succession of air bubbles and plugs of water. According to the Sullivan Machinery Co., the cause of this is as follows: "Pressure is built up in the air passage (until it is sufficient to overcome the head due to submergence) when a large bubble of air passes into the eduction pipe. This flow of air from the pipe temporarily reduces the air pressure through wire drawing, so that the weight of water in the well outside of the eduction and air pipes, which is due to submergence, shuts the air off and a plug of water follows

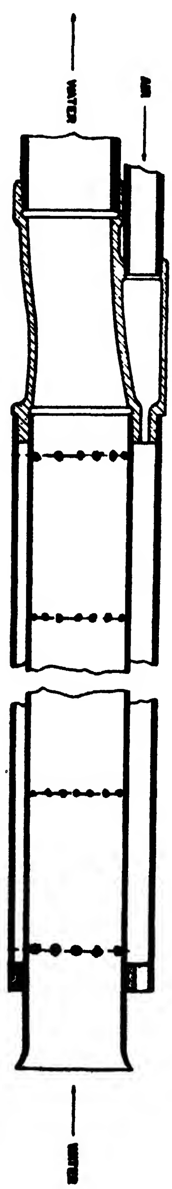


FIG. 6

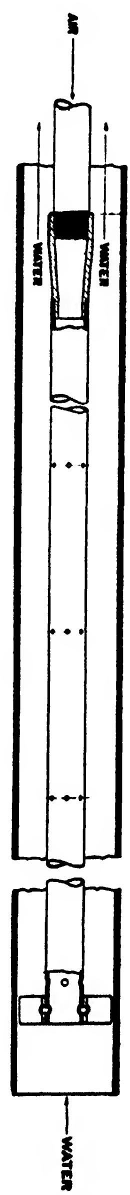


FIG. 7

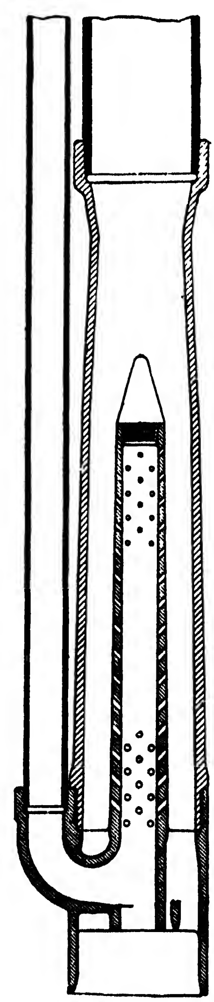


FIG. 8

the plug of air up into the eduction pipe, until the compressor has had time to build up the air pressure and the air again breaks through."

All of these systems have been more or less superseded by more up to date and efficient methods.

Figure 6 shows the Ingersoll-Rand Class V. A. foot-piece which is the type installed at Olaa. As will be seen, the annular feature has been retained but considerably improved upon. It consists of an outside casing with an inside tube of brass, both attached to the Venturi connection which helps to mix the air and water and give the proper acceleration at this point. The Venturi or throat is important and is used in all up to date foot-pieces. The foot-piece is made long enough to permit a series of rings of small holes to be drilled around the periphery of the brass tube. These rings of holes are spaced in such a way as to create sufficient back pressure in the pump so that the air will enter the rising column of water with some speed, thereby again insuring a more thorough mixing with the water. It also helps to overcome the "plugging" effect as described in the older systems.

Figure 7 shows the Central Pipe system made by the same company. This system is practically the same as that just described, the only difference being the introduction of the air through the central pipe. All the other features of the V. A. foot-piece are retained in this style of pump.

Figure 8 shows the Sullivan Standard Air Lift Pump, built by the Sullivan Machinery Company, Chicago. The foot-piece is in the same class as the Ingersoll-Rand V. A. type. The characteristics are practically the same, the only change being the introducing of the air in the center of the rising column of water instead of on the outside.

Figure 9 is the Central Pipe system by the same company. The sketch shows very plainly the throat or Venturi.

Figure 10 shows the Sullivan Type D foot-piece for 8″ and larger sizes. This is a combination of the annular and central systems. It has been found that in the larger sizes of pumps the thickness of the stream of water prevents the air—escaping through the perforations in the central mixing tube—from making a thorough mixture. Therefore by the addition of the outside tube this is overcome.

Although the efficiency of an air lift pump be low, it is probably as high, if not higher, than any other apparatus used to lift water from narrow and deep wells. It is remarkably free from liability to breakdown as there are no valves or any moving parts to get out of order. Stones or sand are no obstacles to it. When our installation was first started numerous stones were thrown out, some of them about 2″ diameter and one piece in particular was about 2½″ diameter by 4″ long. The well can be any distance from the air compressor, provided of course consideration is given to the size of the air pipe leading from the compressor to the well. It requires no attention whatever as it will start and stop as the compressor is started and stopped. This extreme simplicity and the lack of attention required, has a tendency to offset any of its disadvantages.

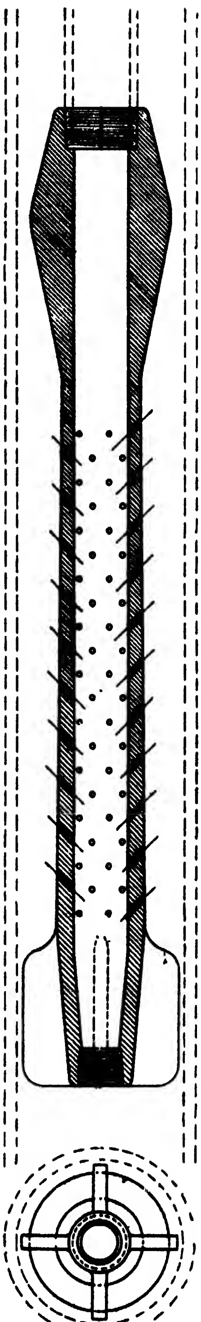
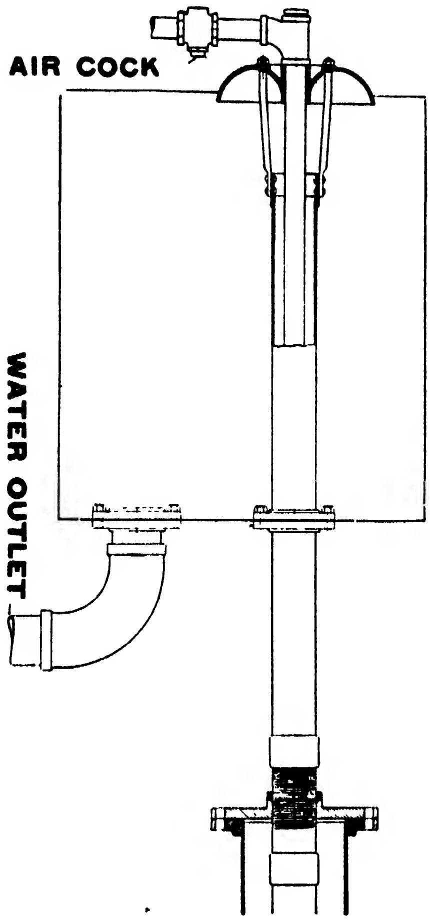


FIG. 9



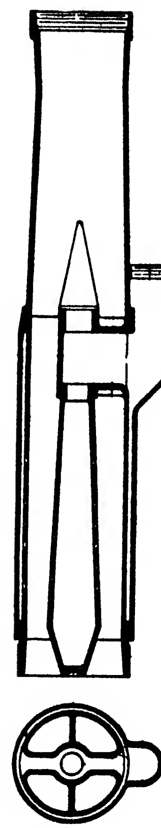
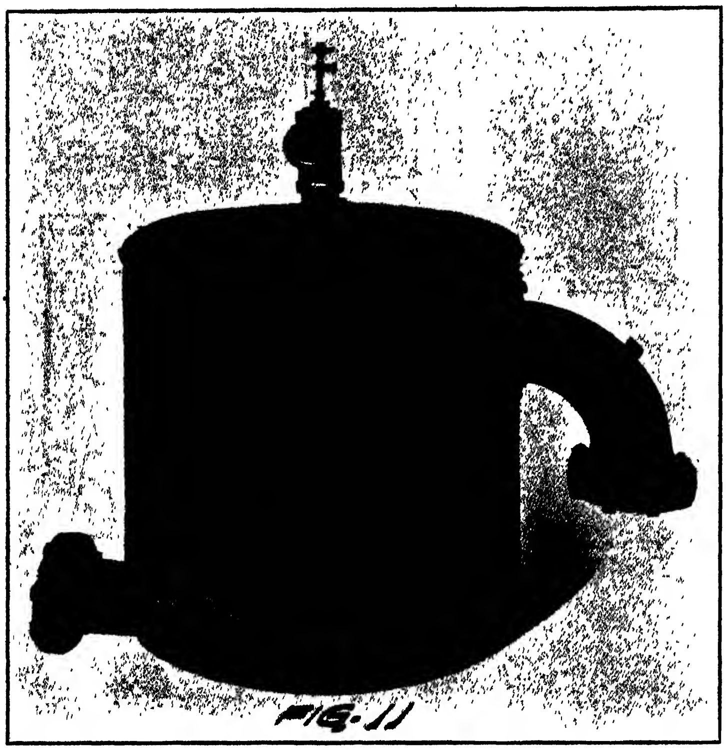


FIG. 10

Water can also be pumped through long horizontal pipes from the air lift proper and again forced to an elevation above the ground surface. This is done by installing a booster on the top of the discharge pipe and using the air a second time after being separated from the water.

Figure 11 shows the Sullivan "Cyclone" Booster while Figure 12 shows the Re-lift Mixing Tube. Figure 13 shows a typical installation, illustrating the air lift, booster and re-lift mixing tube or compound jet.

The booster as illustrated is a simple tank, closed top and bottom, with the inlet and outlet at a tangent to the periphery. The combined air and water from the air lift is discharged into the top at a high velocity, causing it to swirl and effecting in this way a perfect separation of air and water. The water is discharged at the bottom, while the air passes off at the top through the pressure



retaining valve. This valve is set to maintain the pressure required by the head against which the booster is to discharge. The air from the pressure retaining valve is piped to the bottom of the riser pipe where it again mixes with the water through the re-lift mixing tube.

The work to be done by the booster, represented by the lift and friction head, should not exceed 25% of the total working air pressure in the air lift pump.

It is unfortunate that there is no data available at this time in connection with the combined efficiency of the air lift and booster.

To operate efficiently the proper amount of submergence or that part of the air and eduction pipes below the surface of the water in the well, is very important.

In actual practice it has been found that the submergence may be varied with the lift, shorter lifts requiring a greater percentage of submergence. The drop of a well is one of the most uncertain factors in air lift work and cannot be calculated previous to installing the pump. ~~Each~~ well is a separate problem, because (depending on the geology) one well may have a drop of 40 feet while

another may have no drop at all. Owing to this and also on account of the depth of the well and proportioning of the eduction pipe, there is no definite relation between lift and submergence, although the following proportions will be found effective for preliminary calculations:

For lifts to	50 feet	— 70 to 66%	submergence
50 to 100	"	— 66 to 55%	"
100 to 200	"	— 55 to 50%	"
200 to 300	"	— 50 to 43%	"
300 to 400	"	— 43 to 40%	"
400 to 500	"	— 40 to 33%	"

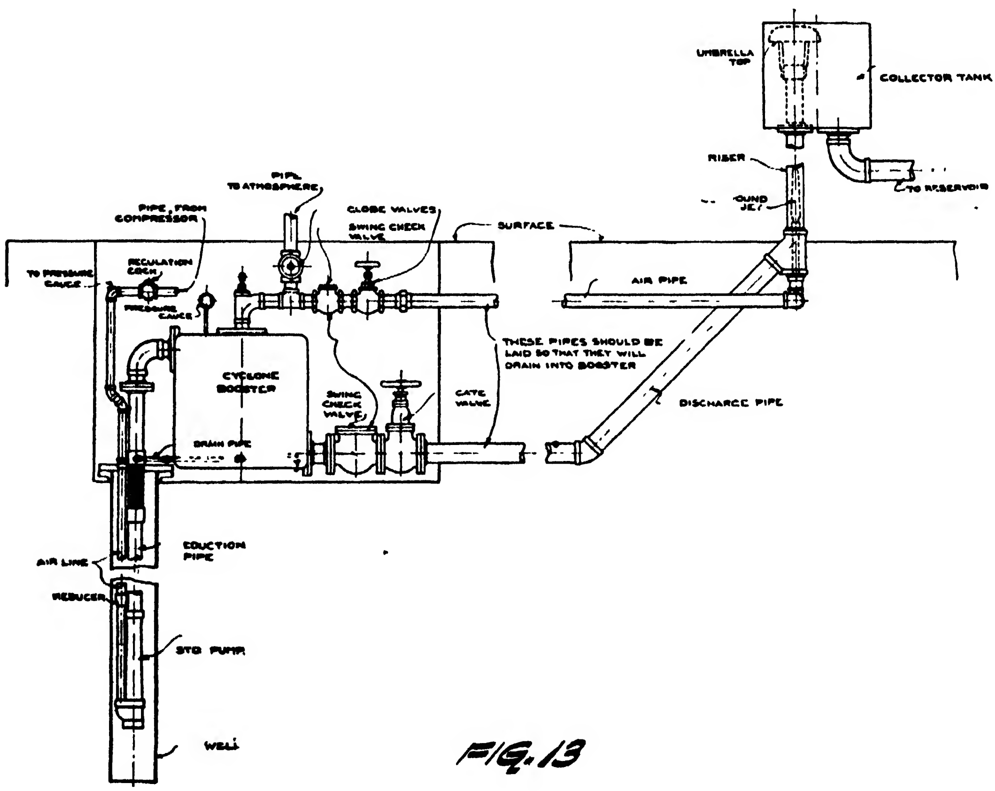


FIG. 13

The proper proportioning of the eduction pipe is also of great importance to secure the highest efficiency. It must bear a relation not only to the amount of water to be handled, but also to the amount of air; so that for an equal amount of water the pipe size may vary with the lift and also with the percentage of submergence, as both factors change the amount of air. If the pipe is too large, there is slippage of the air past the water unless more air is used to keep up the velocity. If the pipe is too small, undue friction will, of course, increase the power needed.

Quoting Prof. Blaisdell: "The velocity of the air and water mixture at the upper end of the discharge pipe will be from three to four times that in the lower portion of the same pipe (if the pipe is of constant diameter throughout),

due to the expansion of the air bubbles as they ascend in the discharge pipe and reduce the effective area for the flow of water. It will serve for most purposes to assume a velocity of from 6 to 8 feet per second for the lower end of the pipe and 18 to 26 feet per second for the upper end." The theoretically correct form of discharge pipe is one that tapers gradually from top to bottom.

Some of the formulas used in air-lift work are here given. In these formulas the letters have the meaning as follows:

Q = Cubic feet per second of water and air.
Qw = Cubic feet per second of water pumped.
q = Cubic feet free air per gallon water pumped.
q_1 = Cubic feet free air per lb. water pumped.
p_1 = Atmospheric pressure lbs. per square ins. abs.
p_2 = Pressure at lower end of air pipe, lbs. per sq. ins. abs.
V = Velocity of fluid mixture at point where air enters discharge pipe, ft. per second.
D = Diameter of discharge pipe in inches.
G = Gallons water pumped per minute.
h.p. = Lift in feet.
N. = % Efficiency.

The quantity of water and air passing by the lower end of the air pipe is given by the formula:

$$Q = Qw\ (7.84\ q\ \frac{p1}{p2} + 1)$$

This formula applies to but one section of the discharge pipe. for any section of this pipe y feet from the lower end of the air pipe, the density of the fluid mass is less than it was lower down in the pipe and Q becomes greater, although the weight of fluid discharging from the pipe per second remains constant.

The diameter of the discharge pipe is given by the formula:

$$D = 0.62 \sqrt{\frac{G\ (7.48\ q\ \frac{p1}{p2} + 1)}{V}}$$

The value of D given by this formula must be less than that of the well by 3" to 5". A suitable value for V is 6 to 8 feet per second. As a rough estimate one can allow about one square inch of free cross sectional area for discharge for every 12 to 18 gallons of water pumped.

Quantity of free air per gallon of water pumped is given by the formula:

$$q = \frac{62.5\ \text{h.p.}}{N\ 16035\ \log_e \frac{p2}{p1}}$$

The efficiency of an air lift can best be stated as:

$$N = \frac{\text{lbs. of water delivered} \times \text{pumping head in feet}}{\text{air compressor work in foot lbs.}}$$

For given operating conditions this ratio will be the same for unit weight of water as for the total weight, providing that the quantity of free air per lb. of water pumped is used in the calculation. Therefore this becomes:

$$N = \frac{1 \times \text{h.p.}}{144\ p_1\ q_1\ \log_e \dfrac{p2}{p1}}$$

For other formulas in connection with the effective length of the discharge pipe and proportioning of same see the before mentioned article in "Power" by Prof. Blaisdell.

Olaa Installations and Results

The Olaa installation consists of one Ingersoll-Rand 10″ and 10″x14″, and 16″ and 10″x14″ steam driven cross compound air compressors and two type V. A. size 8 foot-pieces.

The two original wells of 240′ depth in which the single acting plunger pumps worked, were deepened to 450′. This was necessary to obtain the proper submergence.

The dimensions of the wells are as follows:

Diameter	12″
Depth	450′ 0″
Static Head	203′ 6″
Drop	0′ 0″
Pumping Head	203′ 6″
Submergence	239′ 1½″
% Submergence	54

It will be noted that there is no drop of the static head. This, I believe, is very unusual, but, as was said before, when everything is taken into consideration with reference to the geology, it is not so remarkable.

· The two wells are within fifty feet of each other so that this favors our contention that there was an abundance of water. The wells are about three miles inland but the salt contents of the water is only 0.4 of 1 grain per gallon.

The dimensions of the discharge pipes of the two pumps are as follows:

Well No. 1

Length of Foot Piece				....	6′	10″
First section of pipe	4½″	diameter		......	50′	0″
Second	" " "	5″	"	......	127′	1″
Third	" " "	6″	"	......	124′	9-5/8″
Fourth	" " "	7″	"	......	133′	10-7/8″
Total				....	442′	7½″

Well No. 2

Length of Foot Piece..................	6′	10″
First section of pipe 4½″ diameter......	119′	10-7/8″
Second " " " 5″ "	139′	11-7/8″
Third " " " 6″ "	175′	10-3/4″
Total	442′	7½″

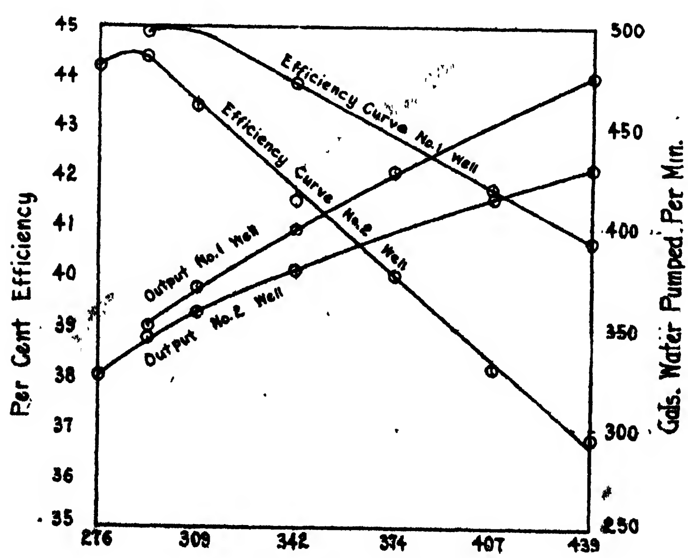
It will be seen that the discharge pipes of the two pumps are not alike. If the efficiency and output chart Figure 14 is studied, the influence, which the proper proportioning of the discharge pipe has on the amount of work done by the pump, will be apparent at once.

The wells were pumped at different compressor speeds varying from 276 to 439 cub. ft. free air per minute, to determine the most economical speed and also to find out the greatest amount of water we could expect if we had occasion to need it.

The following is the result of these tests:

No. 1 Well

Air Cub. ft. per min.	Water Gals. per min.	Water Gals. per 24 hrs.	Water Gals. per Cub. ft. air	Air Cub. ft. per Gals. water
293	350.99	505,425	1.196	0.835
309	370.04	532,857	1.193	0.836
342	400.09	576,129	1.171	0.855
374	428.30	616,752	1.143	0.875
407	452.75	651,967	1.111	0.899
439	476.01	685,461	1.082	0.942



—Efficiency & Output (Gals. Water Per Min.)—
Of
—Wells No. 1 & No. 2 Olaa Hawaii—

FIG. 14.

No. 2 Well

Air Cub. ft. per min.	Water Gals. per min.	Water Gals. per 24 hrs.	Water Gals. per Cub. ft. air	Air Cub. ft. per Gals. water
276	325.86	469,238	1.176	0.849
293	346.70	499,248	1.182	0.846
309	357.65	515,016	1.151	0.865
342	378.40	544,896	1.106	0.904
374	399.00	574,560	1.064	0.939
407	415.40	598,176	1.020	0.980
439	430.40	619,776	0.978	1.022

The air pressure required is of course that due to the submergence. Submergence ÷ 2.3 + friction = Running pressure.

The efficiency of the two pumps as computed by Prof. Blaisdell's formula is:

Air Cub. ft. per min.	% Efficiency Pump #1	% Efficiency Pump #2
276	——	44.22
293	44.97	44.44
309	44.93	43.41
342	43.90	41.57
374	42.96	40.02
407	41.76	38.35
439	40.67	36.78

Acknowledgment is hereby made to the Ingersoll-Rand Co. and Sullivan Engineering for the illustrations used.

Potash Recovery From Waste Molasses*

By Raymond Elliott.

Molasses has been burned at Paauhau during this season for the recovery of ash and potash. A specially constructed furnace is used, the molasses being fed in the form of a thick spray. An analysis of the resulting ash by the H. S. P. A. Experiment Station gives the following as the composition of three months' run:

	Per Cent.
Potash, water soluble	27.66
Potash, acid soluble	28.33
Silica	3.63
Iron and Aluminum Oxides	1.22
Lime	17.67
Phosphoric Oxide, acid soluble	2.00
Phosphoric Oxide, water soluble	trace
Sulphuric Oxide	8.36
Carbon Dioxide	5.39
Chlorine	16.49
Carbon	11.79
Total Water Soluble	55.28

* Abstracted from a paper read at the first annual meeting of the Association of Hawaiian Sugar Technologists, Honolulu, November 15-18, 1922.

The following table gives the results of the operation for three consecutive months. The first two columns show the recovery of ash and potash respectively as per cent of theoretical. The third and fourth columns show respectively the actual potash per cent of the ash and the theoretical potash per cent of ash as obtained from laboratory analysis. In the fifth column is shown the percentage difference between the theoretical and actual potash content of the ash, corresponding to the per cent of the total potash lost.

Ash Recovered, % Ash in Molasses	Potash Recovery, % Potash in Molasses	% Potash in Ash — Actual	% Potash in Ash — Theoretical	Percentage Difference
41.37	32.89	22.60	28.43	20.5
59.24	53.06	25.25	28.19	10.4
72.28	60.11	27.61	33.20	16.8
89.19	79.34	27.74	31.18	10.3
79.00	71.84	27.66	30.42	9.1
87.96	73.48	26.35	31.55	16.5

The order of recovery of ash, potash and the potash content of the ash follows fairly regularly. The writer has observed that this is a direct result of the draft and heat of the furnace, the best recovery following the use of a low draft not to exceed 0.10″ and a low temperature, just sufficient to effect the combustion of the molasses. This is readily explainable by the fact that at relatively high temperature the chloride of potassium, which forms the bulk of the potash salts, is volatilized, a fact which is also shown in the low potash content of the ash when the recovery is also low.

Sugar Loss Due to Burning-Off*

By J. P. Frank.

When cane is burned before cutting, there is found on the stalks a sticky substance, the amount varying with the intensity of the heat to which it has been exposed, being greatest when the cane is unstripped and the trash dry. This so-called "sweating" was examined in the laboratory of the Onomea Sugar Co., and found to be concentrated juice, thus indicating a loss in sugar due to burning in addition to that possibly lost through deterioration of the cane. This is particularly so when the cane is sent to the mill in flumes, when the material on the stalks will be entirely dissolved in the flume water. The work here reported was interrupted by a spell of rainy weather, and is therefore not complete. It is the intention of the writer to make further tests and observations during the 1923 crop. The following figures give the results obtained so far:

Condition of Cane and Fire.	Sucrose in "Sweating" per 100 Sucrose in Cane.
Unstripped Cane, light fire, light burning, wet trash (1)	0.81
" " " " " " " " (2)	0.81
" " light burning	0.96
" " wet trash	1.18
" " normal fire	2.35
" " hot fire (1)	6.08
" " " " (2)	7.46
Stripped Cane, light fire	0.79
" " hot fire	2.43

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* Abstracted from a paper read at the first annual meeting of the Association of Hawaiian Sugar Technologists, November 15-18, 1922.

Returning Mud to the Mill After the First Pressing*

By V. Marcallino

The idea of returning the mud to the mill after its separation from the clear juice is an old one, and has been tried out in many varying forms. The results claimed vary from absolute failure to complete success.

At Waiakea, the experiment of returning mud to the mill after the first pressing was started at about noon on Friday, August 18. It was continued all day Saturday and on Monday, the 21st, until 4 p. m. The immediate cause of its discontinuation was the difficulty encountered in getting the juice to settle in the clarifiers, resulting in the blocking of this station.

Double pressing is practiced at Waiakea. It was thought that after one pressing and remixing with water, the volume of the mud juice would have been so reduced as to make its return to the mill possible, also that its sucrose content would be so low that there would be no effects harmful to the extraction.

Object of the Experiment.

Four men are employed on the mud press station, two on the first presses, two on the second. Had the experiment been successful, it would have meant the elimination of two men and of all the cloth used in the second presses. In 1921, with a crop of 9380 tons, the quantity of cloth used on the second presses alone was 1720 yards. A certain amount of inversion is always to be found where double pressing is practiced. This should have been reduced.

Procedure.

There was no change made in the equipment, other than the running of a pipe from the pump supplying the second presses to the mill. This pipe was lead into a trough located just behind the first mill and here the mud juice mingled with the last mill juice, the overflowing of the trough causing the mixture to sprinkle over the bagasse blanket.

The mud juice, after the first pressing, and the last mill juice being of approximately equal densities, it was felt that this was the proper place to return the mud. The time allowed for the admixture of the mud and bagasse blanket was therefore the time taken by the bagasse blanket to travel between the first and second mills. As the crusher was not in use at the time of the experiment, the second mill juice went directly to the mixed juice tank.

Results.

It was noted that a considerable proportion of the mud returned was re-expressed by the second mill and reentered the mixed juice. The increased volume of mud in the clarifiers retarded the settling to such an extent as to greatly lessen the proportion of clear juice which could be drawn off, and at the

* Presented at the First Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, November 15-18, 1922.

same time, increased the quantity of mud to be handled by the first presses. This resulted in the congestion of these two stations and was the immediate cause of the discontinuation of the experiment.

The above is true in spite of the fact that the average tonnage per hour for these three days was only 21.3, as against 25.0 for the balance of the crop, and that out of a total time of 37 hours there were delays amounting to 3 hours and 45 minutes, which time was available for settling. The dilution, however, for these three days averaged 32.3 as against 27.5 for the balance of the crop.

Bagasse samples taken during the period of the experiment both when the mud was being returned and when such was not the case, point to the conclusion that the extraction would have suffered somewhat, had the procedure been continued. To just what extent, however, the writer would not care to hazard a guess, owing to the short duration of the test and the lack of conclusive figures.

It may also be noted that during the progress of the experiment, several complaints were encountered from the firemen, who claimed that the bagasse did not burn as well, owing to a higher moisture content and the presence of the mud.

Discussion of the Results.

It seems that the principal reason for the failure of the experiment was that a large proportion of the mud once removed from the clarified juice found its way back into the mixed juice, resulting in an ever increasing volume of mud in the settling tanks. In other words, the bagasse blanket of one mill alone did not constitute a proper filtering medium, a large proportion of the mud finding its way into the expressed juice instead of being retained in the bagasse.

Had the mud juice been returned after the second mill instead of after the first, the last mill juice containing the expressed mud could have been returned ahead of the second mill, probably resulting in a better filtration. It was felt, however, that the returning of the mud juice high in sucrose content just ahead of the last mill, would have had a detrimental effect on the extraction. Or, if the crusher had been in operation at this time, the second mill juice could have been returned ahead of the first mill. It is possible that with a longer train of mills, where the returning of maceration could be practiced, a more satisfactory filtration could have been obtained.

It may be noted that during the progress of the experiment the juice from the clarifiers was more strongly alkaline than is usually the case at Waiakea. No attempt was made to speed up the rate of settling by decreasing or increasing the amount of lime used.

Sugar Formation and Ripening of the Sugar Cane*

By J. Kuyper.

(Abstracted by W. van H. Duker)

The first part of this publication describes how the formation of organic matter depends on the leaf green (chlorophyl) and the light energy.

The quantity of light energy is fixed and the growing period should be so arranged that this quantity is used to best advantage. Everything in connection with the crop must be so arranged that as large a quantity as possible of the leaf green (chlorophyl) is exposed to the light; it is therefore of advantage to a variety when it has a deep green color, an overhanging foliage and a wide leaf. For this reason healthy cane has the advantage over yellow stripe diseased cane, because the latter contains less chlorophyl. The plant shape should be so that the entire surface is covered by leaves.

Binding of canes works detrimentally on the production ability, because as the tops are tied together the light energy is not fully utilized. Tying up is therefore a cure for fallen cane, which at times can turn out to be definitely detrimental.

Under otherwise comparable circumstances high cane weight usually goes together with a lower rendement, a lower cane weight with a higher rendement. However, a favorable year in comparison with an unfavorable one will give a higher rendement, because favorable weather conditions give to the cane a better chance to ripen. Early harvesting is nearly always less risky than late harvesting.

In the second part the ripening and ripeness determination is treated. In the first place the sampling is discussed. The best system is a definite location on a field map of the spots where the samples are to be taken, and long before the samples are analyzed to label the stalks to be used. The choice of the stalks is therefore perfectly automatic. It is immaterial if the stalks originate from one or more seedpiece. The reliability of this method is discussed in detail.

In Chapter III, on the analysis of the samples, is first proven that sampling for cane weight is practically impossible and that therefore the juice figures deserve our special attention. Later they take up why the three-division of the stalks is the best method of analysis. In detail is described how this method is developed and on what scientific base it rests. The division of the stalk in 10 parts gives interesting data but is too elaborate for practical use; examination of 2 parts causes the most important advantages of the division method to be lost. The method does not hold good for just a few varieties; but, based on physiological reason and on examples taken from practice, the conclusion is drawn that between cane varieties no principal difference exists.

In Chapter IV, on the Interpretation of Advance Analyses Results, methods are developed how the figures from the advance analysis books can best be combined to obtain a survey of the available material. The fields are therefore arranged in groups with the same plant month. From the thus obtained figures it is shown how the ripening depends on the plant month; for 100 P.O.J. this

* Archief voor de Suikerindustrie in Nederlandsch Indie, 1922.

dependability is greater than for 247 B; for the factory at Remboen the figures check closer than for Gempolkrep. The curves for the average sucrose content is also different for both plantations, but from this the conclusion is drawn that the ripening differs for cane varieties and plantations. It is shown that two main groups of plantations must be considered; those where soil and climate are favorable to a slow ripening in the east monsoon, and those where soil and climate first accelerate ripening in the east monsoon but thereafter break off quite suddenly. On the first named plantations later planted fields can reach the same rendement as the earlier planted; in the latter group the later fields usually only reach a lower rendement. The influence of the climate on the ripening for different years is traced.

Chapter V deals with the differences between the three parts where in the stalk is divided. Here also the just mentioned division holds good. It shows that on a plantation with a strong east monsoon for all canes, irrespective of the plant month, the differences of lower-center equal the difference of center-top, that therefore in the graphic representation the lines cross at about the same datum. For a plantation of the Remboen type this is not the case.

It happens repeatedly that the difference of lower center becomes negative, and more especially for certain cane varieties as D.I. 52, for others less so, and for 247 B practically never. The connection of this phenomenon with the rainfall is shown. The comparison between the plantations Remboen and Gempolkrep is again extensively carried through on the basis of what is said in previous chapters. At the end of this chapter a review is given of the behavior of several cane varieties on different enterprises; while a classification is studied of how far cane varieties and enterprises should be arranged in the before mentioned groups.

In Chapter VI a study is made as to how W.S. (available sucrose) Brix and Purity change in the three parts of the stalk under the influence of outside circumstances, especially rain. It shows that the lower part reacts first and strongest on minor factors such as light rains. The Purity shows the strongest fluctuations of irregularities in the ripening, a large drop of Purity in all parts points to large disturbances, especially if this coincides with a drop in the Brix. The character of the reaction of the juice is the same for varying age, and therefore in order to determine the moment of ripeness next to these variations in juice properties, the characteristics of every cane variety and each plantation must be known.

In Chapter VII, on the glucose, we find that the glucose factor shows variations in nearly perfect agreement with the fluctuations in the usually determined juice figures. Based hereon is reasoned that the determination of the glucose percentage has only doubtful value considering the additional work required.

In connection with the Specific Gravity in Chapter VIII, we find that up to the present this has been of no value in the determination of the time of ripeness, also the chance that this will give a better indication in the future is small. At its best it furnishes a control on certain characteristics in the stand (for instance, presence of diseased cane) and only as study-material do the Specific Gravity determinations have value.

Investigations Pertaining to the Field Rat and Other Problems in Hamakua.

A Report on Progress of Work

By C. E. Pemberton

On January 5th of this year, I commenced an investigation of the results obtained from the application of rat poison in all of the cane fields at Honokaa during the year 1922. As each field is harvested, I am making counts of average cane in all parts of the field to obtain as exact figures as possible on the amount of rat damage present. I have made every effort to secure a fair count. I believe the accumulating data will fall close to the average condition of each field. The preliminary results have reached fair proportions, and I am submitting them at the present time for the interest they possess. The accompanying table summarizes the results. For interesting comparisons I am including a table on the extent of rat damage at Honokaa to cane, cut during 1922, which was unpoisoned excepting in limited areas under experiment. These figures were kindly supplied me by the Honokaa Sugar Co. I have also added a table showing the enormous amount of rat damage occurring in cane at Pacific Sugar Mill, cut during 1922. These figures were also supplied by Honokaa Sugar Co. I have made a few counts with Mr. F. R. Giddings, of cane harvested this year at Pacific Sugar Mill, and include them in the first table. The treatment for rat control of the fields at Pacific Sugar Mill does not seem to have been satisfactory. The amount of rat-eaten cane now present there would also seem to indicate this. The control in some sections will be difficult and require very close supervision in the application of poison. It will probably prove necessary to place poison in those parts in greater quantity and more frequently than in average fields, both at Honokaa Sugar Co. and Pacific Sugar Mill. The condition of the fields at Pacific Sugar Mill will thus this year serve to some extent as a check on the results obtained at Honokaa, where the poisoning during 1922 was intensively done and thorough in most areas.

The average damage to cane harvested to date at Honokaa, as computed from the data in Table 1, is 3.2%. The fields from which this cane was cut were poisoned thoroughly in 1922. The average damage by rats to cane at Honokaa harvested during 1922, as taken from Table 2, was 19%. This cane was not poisoned, except experimentally in some places. This comparison is highly illuminating and rather indicates that the first year of the poison campaign at Honokaa, with all its seemingly insurmountable difficulties and doubts as to the final results, has proven an economic success. There should be much greater improvement during the coming year through more efficient manufacture of the poison, its more systematic application, and through much added knowledge of the distribution and habits of the rat and the quantity of poison to apply. Table 1 shows parts of some fields still with from 5 to 15% rat injury. These places are almost invariably next to gulches or are deep hollows or pockets containing rock-piles or waste areas of great irregularity. Here the rats have a better

foothold, can develop and congregate with but little disturbance, and it is here that poison will need to be applied in maximum quantity and frequency. The parts of Honokaa fields showing the most injury received about the same amount of poison as the less damaged parts. The quantity and frequency of application will probably have to be doubled at such places in the future. Field 38, Honokaa, shows some places with a fair amount of rat damage, in spite of the poisoning I am told that this cane was in some parts fairly mature before the first application of poison was put on, and that rat injury was then present. This does not account for all the injury, however, Several fields will show a good deal of old injury, owing to the age of the cane. Field 34 is now being harvested. This field is two years old and had considerable rat-eaten cane in it before the first poison was put on in 1922. It seems to illustrate very well the efficacy of the poison, for practically all of the injury is old.

Most of the Honokaa fields which were poisoned received three applications. Mr. F. R. Giddings of Honokaa Sugar Co. has given me the data included in Table 4, showing just what treatment each field received. It should be noted that strychnine-wheat was not applied until the close of the year and thus practically all of the results were obtained from the first two treatments with barium carbonate cakes. I believe four applications a year in average fields will prove worth while, instead of three. At least the first two should not be more than three months apart. A consideration of the breeding habits of the rat must be taken into account. Three months after the first poisoning, many young rats which were too small to move about much for food when the first application was made, will have missed the poison, which the adults have readily found, and be old enough for reproduction. This brood, just maturing, will be important to eliminate as far as possible. In other words, the quantity of young left in the field after the first poisoning should be large, while the number present at the time of the second poisoning, three months later, should be small. This is the basic principle governing the artificial control of many insect pests, and should hold true in rat control, within reasonable limits, if the poisoning is thorough.

Bubonic plague has again appeared among rats in Hamakua, the first for the year 1923. Mr. C. Charlock of the Territorial Board of Health has diagnosed the cases of three rats as positive for plague. Two came from Field 19, Pacific Sugar Mill, and one from the Louisson-Vanatta Road above Paauilo. It is interesting that all three rats were taken outside the region at Honokaa where the rats have been so greatly reduced. Rats have done a great deal of damage in Field 19, Pacific Sugar Mill, where two of the infected individuals were taken. Mr. Charlock has supplied me with slide mounts of the plague bacilli secured from these three plague rats. They are proving useful for comparison with numerous bacteria which I am daily securing from fleas and mites collected from rats, for plague investigations.

Cane Borer Damage

While carrying on [illegible]matic examination of cane for rat injury as it is cut in each Honokaa [illegible]ave been constantly confronted with rather extensive cane-borer inj[illegible] have been making counts in each field since February

7th, to secure the percentage of borer-injured cane. The injury is in excess of what was expected. In fact, the damage by borer this year must amount to many thousands of dollars if the percentages continue to run as high as those obtained in the counts to date. I have used every precaution to count only average unselected cane. The following table covers all the examinations made. Mr. Waldron and Mr. Naquin are particularly interested in having me secure these data. I have been told that the borer has always been somewhat serious here.

BORER-INJURED CANE, HONOKAA SUGAR CO., 1923

Date	Field	Variety	No. Sticks Examined	No. Sticks Injured	Percentage Injured
Feb. 7	30	D 1135	200	107	53.5
" 8	18	H 109	100	36	36
" 8	18	D 1135	100	58	58
" 9	18	"	100	32	32
" 12	37	"	200	101	50.5
" 12	30	"	100	63	63
" 13	30	"	100	49	49
" 14	37	"	300	132	44
" 14	30	"	100	39	39
" 15	18	"	200	39	19.5
" 16	19 (Kukuihaele)	"	100	29	29
" 17	18	"	200	30	15
" 19	34	H 109	300	174	58
" 20	34	"	600	244	40.6
				Average	41.9

Parasitized borers are easily found in any field, but for some unexplained reason, the parasite does not hold the borer in check as well as on most other plantations in the Islands. As the examinations for rat-injury progress, I will collect with these data further information on the extent of borer-injury in each field as it is harvested.

Wireworm Investigations

Two field experiments on wireworm control have been put out, using cyanamid and carbon bisulphide. A field for the cotton-seed meal experiment should be ready for planting in a few weeks. The cyanamid experiment covers an area 80 by 60 yards, using 400 lbs. of cyanamid, placed in the furrow with the seed before it is covered. I placed this in the furrows ahead of the planters, spreading it well out to cover the bottom of the furrow at a width of about 1½ feet. Suitable check-rows were untreated. I do not believe the cyanamid will prove of any value in checking wireworms. It has no effect upon them that I could detect in laboratory experiments. Fifty wireworms were placed in a 2-quart can of soil on January 16th and two ounces of cyanamid mixed thoroughly in. This is a much greater strength than could ever be used in the field. On February 20th, the wireworms were still healthy and active, barring those which had been destroyed through the cannibalistic habits of the wireworms. In another laboratory test on January 12th, 100 freshly-collected wireworms were placed in a wooden box containing ½ cubic yard of soil into

which 4 ounces of cyanamid was thoroughly mixed, and 4 seedpieces of D 1135 planted. This is at a rate of over 1 ton cyanamid per acre. By February 20th, the cane had germinated satisfactorily, the root-systems were large with no visible cyanamid injury, and the wireworms were still alive and active. None of the cane-eyes had been eaten by the wireworms, however, after the 39 days of confinement in the box with the seed. The material may have had some injurious effect upon the wireworms which could not be detected. The cyanamid may thus act as a repellant. The field experiment will require a few weeks more before the results are known.

In the carbon bisulphide test against wireworms I gassed 22 rows, 150 feet long, following the planters, leaving proper check-rows, using the Danks Injector and applying about 1 gallon of carbon bisulphide per 500 feet of row . A charge of gas was put in at about 1½ feet spacing. I hoped in this way to kill outright the majority of the wireworms in the soil for a distance of about 1½ feet about the seed. It is yet too early to know the results of this test.

TABLE 1.
RAT-DAMAGE—HONOKAA SUGAR CO.
FIELDS POISONED 1922—HARVESTED 1923.

Field	Variety	Date 1923	No. Sticks Examined	No. Sticks Rat-eaten	Percentage Sticks Eaten
20	H109 & D1135	Jan. 5	1500	10	.6
	" "	" 6	500	1	.2
	Badila	" 17	1000	0	0
	D1135	" 17	1000	29	2.9
	"	" 17	*2000	22	1.1
33a	H109 & D1135	" 22	2000	22	1.1
	H109	" 26	1400	56	4.0
	"	" 27	2000	59	2.9
	D1135	" 27	600	10	1.6
30	D1135	" 9	500	6	1.2
	"	" 10	1000	8	.8
	"	Feb. 5	*1000	35	3.5
	"	" 6	3000	57	1.9
	"	" 7	2000	49	2.4
	"	" 12	1500	119	7.9
	"	" 13	1000	84	8.4
	"	" 14	1000	35	3.5
13	"	Jan. 17	*2000	1	.05
	"	" 25	*3000	31	1.03
	"	" 30	3000	35	1.01
37	"	Feb. 7	2000	81	4.05
	"	" 12	2000	88	4.4
	"	" 14	2000	82	4.1
38	"	Jan. [illegible]	2000	51	2.5
	"	" 23	1000	51	5.1
	"	" 24	1000	64	6.4
	H109	" 24	1000	22	2.2
	"	" 29	1500	229	15.2
	"	" 30	1000	99	9.9
	D1135	" 30	1000	105	10.5
	H109	Feb. 5	*1000	119	11.9

Field	Variety	Date 1923	No. Sticks Examined	No. Sticks Rat-eaten	Percentage Sticks Eaten
18	"	Jan. 23	3000	74	2.4
	"	" 24	*2000	51	2.5
	"	" 29	2000	39	1.9
	D1135	" 29	2000	65	3.2
	"	Feb. 4	1700	37	2.1
	"	" 5	1300	46	3.5
	H109	" 8	3000	37	1.2
	D1135	" 8	3000	30	1.0
	"	" 9	1000	29	2.9
1a	"	" 15	2000	5	.2

EXAMINATIONS AT KUKUIHAELE (PACIFIC SUGAR MILL).

Field	Variety	Date 1923	No. Sticks Examined	No. Sticks Rat-eaten	Percentage Sticks Eaten
9	H109	Jan. 13	1300	221	17.0
19	D1135	" 13	*1340	345	25.8
	D1135	Feb. 5	*1500	590	39.3
	Striped Tip	" 16	*2000	962	48.1

* Count made with Mr. F. R. Giddings.

TABLE 2.

RAT DAMAGED—HONOKAA SUGAR CO.
CANE HARVESTED 1922—UNPOISONED

Field	Date 1922	No. Sticks Examined	Percentage Sticks Eaten
2	May	2800	24
33	"	1000	15
37 B	"	900	25
Chow Choy Contract	"	300	31
1	June	1300	15
2	"	900	26
21	"	300	10
27	"	2000	21
33	"	2500	17
37 B	"	100	22
Chow Choy Contract	"	800	22
1	July	1300	18
21	"	300	14
27	"	1500	16
33	"	1200	16
17	August	600	11
19	"	1400	19
21	"	800	13
24	"	1200	21
27	"	2200	29
28	"	700	16

TABLE 3.

RAT-DAMAGE—PACIFIC SUGAR MILL.
CANE HARVESTED 1922—UNPOISONED.

Field	Date 1922	No. Sticks Examined	Percentage Sticks Eaten
6	June	700	39
8	"	1800	37
14	"	1500	34
23	"	1200	31
5	July	400	10
8	"	1100	55
9	"	300	78
14	"	1800	29
13	August	600	26
5	"	1100	17
24	"	2800	40
22	"	500	7
9	"	800	67
9	September	500	40

TABLE 4.

RAT-POISON APPLICATION, YEAR 1922—HONOKAA SUGAR CO.

Field	Date	Poison	Date	Poison	Date	Poison
1a	June 17	Barium-Carbonate	Nov. 7	Barium-Carbonate	Dec. 20	Strychnine Wheat
5	May 22	"	" 11	"	" 21	"
6	July 19	"	" 9	"	" 21	"
7	" 31	"	" 8	"	" 22	"
10	" 18	"	Oct. 25	"	" 28	"
11	" 19	"	" 30	"	" 22	"
12	" 22	"	Nov. 4	"	" 23	"
13	" 26	"	" 6	"	" 24	"
17	May 31	"	" 2	"	" 20	"
18	" 25	"	Oct. 30	"	" 19	"
20	" 20	"	" 24	"	" 21	"
25	June 15	"	" 20	"	" 27	"
26	" 17	"	" 21	"	" 22	"
28	" 26	"	" 23	"	" 24	"
29	" 30	"	" 19	"	" 27	"
30	July 12	"	" 13	"	" 22	"
33a	May 29	"	" 23	"	" 19	"
34	Mar. 22	"	" 10	Strychnine Wheat	" 8	"
36	June 14	"	" 16	Barium-Carbonate	" 20	"
37	" 30	"	" 4	"	" 22	"
38	July 8	"	Sept. 30	"	" 18	"

Note: Fields 28 and 29 were treated (partially) with strychnine-barley on April 26 and March 11 respectively.

Mongoose

I believe mongoose could be greatly reduced about houses and camps where they destroy poultry, by the adoption of a method which I have tried here with the mongoose in captivity. I have repeatedly killed them, without a single failure, by giving them dead mice poisoned with from 1 to 2 grains of potassium cyanide. I have frequently noticed how quickly, in the field, a mongoose finds and eats a dead rat or mouse. In one instance I had placed a quantity of rat poison in a certain field and early on the following morning counted 18 dead mice close to the poison, in various parts of the field where it was placed. The mice were not touched and on the second day were again looked for. The entire 18 were missing and mongoose excrement, full of hair, was found at a number of the poison spots. This same sort of observation has been made many times during the past 8 months. These observations led to confined experiments, using dead rodents into which a strong poison, such as potassium cyanide, had been inserted. I found that mice are best for this purpose, since the mongoose usually gulps it down dog-fashion, swallowing everything, including head, teeth, claws and all. By making a small incision in the abdomen and inserting a piece of cyanide the size of a pea, or somewhat less, an ideal bait was made. The mongoose never rejected the bait and always died after eating it. They will readily eat a dead mouse if it has not commenced to decay. For those who cared to go to the trouble of setting a few traps for mice, treating the freshly-caught mice as above described and then placing them in places outside poultry yards, where the mongoose have been seen, I believe profitable results would follow. In cane fields where rats are destructive, the mongoose does more good than harm, both in the destruction of rodents and insects.

I have tried feeding the mongoose with rats and mice which have died from eating strychnine-wheat and barium carbonate cakes. The dead rodents are readily eaten, but there is no poisoning effect on the mongoose. One individual was fed 42 mice poisoned and killed with strychnine-wheat or barium carbonate cakes and one rat poisoned with barium carbonate, between October 30, 1922, and November 22, 1922. It remained healthy and active the entire period and completely consumed the rodents whenever they were given. This individual was then killed in a few hours' time by feeding it a mouse containing potassium cyanide. Usually the mongoose will not readily eat poisoned beef.

Any poison procedure for mongoose, if followed as above, would, of course, be dangerous to dogs, cats, etc., that might pick up the poisoned, dead rodent, while potassium cyanide is a dangerous poison to man, even in small quantities.

The assertion is frequently made that the mongoose will eat cane. I have been unable to induce a mongoose to eat cane, even when nearly starved. I have tried cane containing borer-grubs and likewise secured only negative results.
March, 1923.

Safety Involved in Use of Pressure Gages*

Proper Location, Well Arranged Connection Scheme, and Frequent Testing of Gages Necessary for Safe Operating Conditions.

As a part of the high pressure piping system, gages, their use, installation and care are of importance from the standpoint of safety as well as the operating viewpoint. Although progress has been made in gage manufacture until these instruments are quite rugged and extremely reliable, nevertheless there are certain points which must be considered which add to their accuracy and therefore to the over-all safety of the plant.

In its report, the Boiler Code Committee of the A. S. M. E. has this to say regarding steam pressure gages: "Each boiler shall have a steam gage connected to the steam space or to the water column or its steam connection. The steam gage shall be connected to a siphon or equivalent device of sufficient capacity to keep the gage tube filled with water and so arranged that the gage cannot be shut off from the boiler except by a cock placed near the gage and provided with a tee or lever handle arranged to be parallel to the pipe in which it is located when the cock is open. Connections to gages shall be of brass, copper or bronze composition.

"Where the use of a long pipe is necessary, an exception may be made to the rule that the gage must be arranged so that it cannot be shut off except by a cock placed near the gage and a shutoff valve or cock arranged so that it can be locked or sealed open may be used near the boiler. Such pipe shall be of ample size and arranged so that it may be cleared by blowing out. The dial of the steam gage shall be graduated to not less than one and one-half times the maximum allowable working pressure on the boiler. Each boiler shall be provided with a ¼-in. pipe valved connection for the exclusive purpose of attaching a test gage when the boiler is in service, so that the accuracy of the boiler steam gage can be ascertained."

One method of making the gage connections and which conforms to the recommendations just cited is that shown in Fig. 1. In this scheme, as is frequently the case, provision has been made at the top of the water column for the gage connection. The cross A is used and a valve B is placed in the gage line. At C is the section of the piping that provides the water seal and prevents the steam from coming in contact with the gage mechanism. Arrangement for a test connection is made by placing an angle valve at D.

Quite frequently it is desired to place a high pressure steam gage on a central board located on the boiler room floor. This is permissible if done in accordance with the rules given by the A. S. M. E. Code.

One such scheme is shown in the left-hand part of Fig. 1. In this case, the valve E must be locked in the open position and it is also necessary to make provision for blowing out the pipe line. The valve J can be closed, valve E closed and plug G removed, which allows the water to drain out. Valve E may then be opened and the line blown out. The line may then be filled with water at F.

*Power Plant Engineering, Vol. XXVII, No. 1.

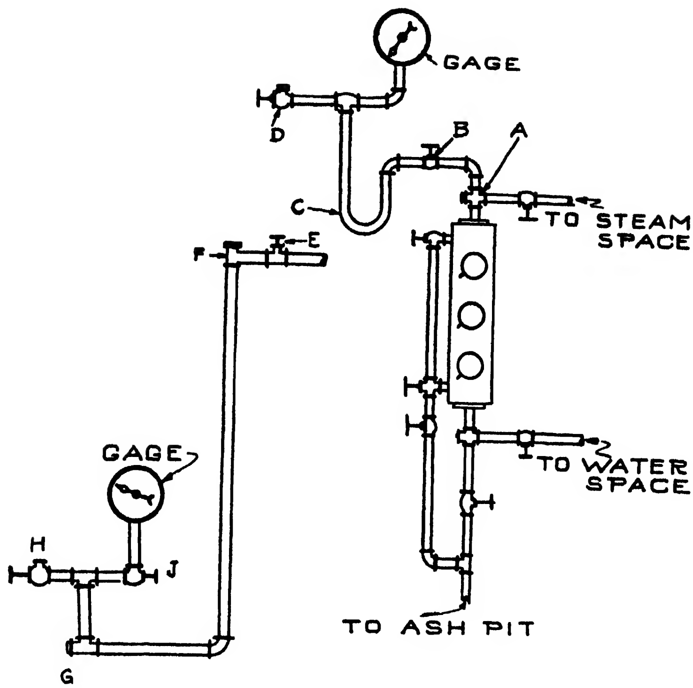


Fig. 1. Gage Connections Are Important Both for Accuracy and Safety.

As there is little danger of the connecting pipe clogging up it is not customary to blow out such lines except at long intervals.

It will be noted that the water seal extends up to F and is maintained at that level by condensate. As this adds a head to the gage reading, proper account must be taken of this in the calibration of gages so located. This can be done by setting the gage at zero with the valve E closed.

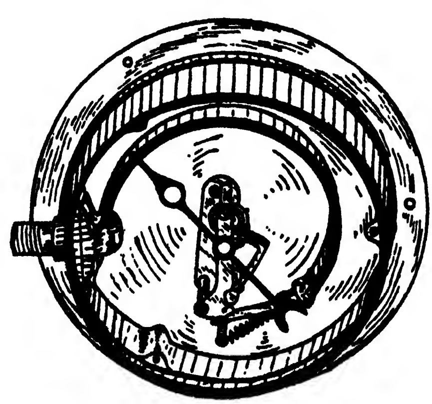


Fig. 2. Mechanism of a Typical Bourdon Pressure Gage.

Even where a gage is used on a panel on the boiler room floor, it is also considered good practice to have a gage at the water column.

Types of Gages

For purpose of indicating pressures, three general types of gages are employed, the Bourdon type, the diaphragm type and the manometer or U tube. Gages of the Bourdon and diaphragm types consist of two essential parts, the pressure element and the movement.

In gages of the Bourdon type, pressure is applied internally to an elastic hollow brass or steel tube of oval section, bent into the shape of a circular arc and closed at one end. Since the closed end of the tube is free to move, while the other end is fixed, fluid pressure on the inside tends to increase the short diameter of the section, causing the radius of curvature of the whole tube to become larger, thus moving the free end a distance proportional to the pressure applied. By connecting a suitable multiplying mechanism to the end of the tube a spindle or pointer may be moved so as to indicate on a graduated dial the pressure in the units desired.

Generally the multiplying mechanism is made up of one or more levers, a toothed segment or sector, a pinion and a hair spring. Adjustment of the ratio of movement between the pointer and the end of the tube is made by either a slotted sector rim or a connecting link, the length of which may readily be changed to suit conditions. Lost motion of the parts is taken up by the hair spring attached to the spindle carrying the pointer.

Owing to pointer vibration due to jarring which occurs in certain classes of service, also the rapid fluctuations of pressure sometimes encountered, double-spring gages are frequently employed. The pressure tubes in such a gage may consist of two separate branches or may be continuous; but in either case, there are two free ends, which, when properly connected by a lever mechanism, give a greater pointer movement than is obtained with a single spring.

In the diaphragm gage, the indicating device is actuated by a corrugated metal disk or diaphragm, clamped around its edges by the flame of an encircling chamber. The deflection of the diaphragm is proportional to be pressure applied to its lower side, and its movement is communicated to the pointer by a mechanism similar to that used in the Bourdon type.

Bourdon gages can be used for indicating pressures of liquids, steam or gases, where the tube does not reach a temperature much in excess of 150 deg. F., as above this limit the temper of the tube is likely to be affected. When used for steam pressures, therefore, a siphon must always be employed to prevent steam coming into contact with the tube, and should be of sufficient capacity to fill the gage tube with water.

Calibrating Pressure Gages

Gages may be checked for accuracy and calibrated by means either of comparison with a standard gage or the use of a dead-weight testing device, such as shown in Fig. 3. This tester consists of a stand from which rises a cylinder, having accurately fitted into it a piston with an area of 1.5 sq. in. which moves freely up and down. Attached to the top of the rod is a disk for the support of the weights; each weight is marked with the number of pounds pressure per

square inch that it will exert on the gage. From the bottom of the cylinder, two tubes project; one from a standard for holding the gage to be tested while the other, inclined, serves as a reservoir for oil and is fitted with a screw plunger.

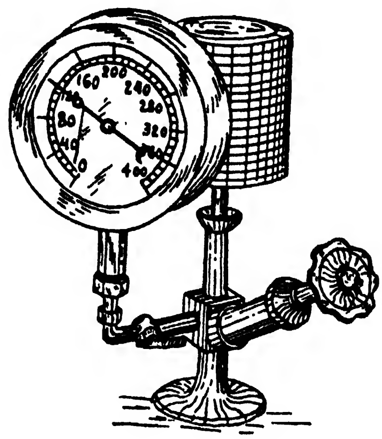


Fig. 3. Gages Are Usually Calibrated by Means of a Dead Weight Tester.

After the gage under test is attached and the three-way cock placed horizontally, the reservoir is filled with oil. This is done by turning the plunger inward to the extreme of its travel and pouring oil into the cylinder until filled; the plunger is then gradually withdrawn and at the same time more oil is added, continuing this until the plunger is in its outer position and with the cylinder nearly full.

With the cock under the gage open, the piston is inserted, which with its disk will indicate a pressure of about 5 lb. on the gage. The weights, one at a time, may now be placed on the disk which should be gently rotated to insure perfect freedom of motion to the piston. Each weight added will indicate a pressure on the gage equal to the number of pounds marked on it, and if the reading of the gage does not correspond to the total number of weights added, corrections of readings will have to be made for the error.

If, in testing a large gage, the piston descends to its full length, screwing in the plunger will force it upward, thus allowing the addition of more weight as may be required.

[W. E. S.]

Sugar Prices.

95° Centrifugals for the Period December 16, 1922, to March 15, 1923.

Date	Per Pound	Per Ton	Remarks
Dec. 27, 1922...	5.65	$113.00	Cubas.
" 29	5.59	111.80	Cubas 5.65, Porto Ricos 5.53.
Jan. 4, 1923...	5.53	110.60	Cubas.
" 6	5.46	109.20	Cubas.
" 8	5.40	108.00	Cubas.
" 9	5.31	106.20	Porto Ricos 5.28, Cubas 5.34.
" 10	5.34	106.80	Cubas.
" 11	5.37	107.40	Cubas 5.40, 5.34.
" 16	5.28	105.60	Cubas.
" 17	5.225	104.50	Cubas 5.24, 5.21.
" 18	5.085	101.70	Cubas 5.15, 5.02.
" 23	5.02	100.40	Porto Ricos.
" 26	5.21	104.20	Cubas.
" 31	5.26	105.20	Porto Ricos 5.24, Cubas 5.28.
Feb. 1	5.37	107.40	Cubas 5.40, Porto Ricos 5.34.
" 2	5.53	110.60	Cubas.
" 5	5.46	109.20	Porto Ricos.
" 6	5.53	110.60	Porto Ricos.
" 8	5.7133	114.266	Porto Ricos 5.65, 5.71, Cubas 5.78.
" 9	5.78	115.60	Cubas.
" 15	6.53	130.60	Cubas.
" 19	6.905	138.10	Porto Ricos 6.90, Cubas 6.91.
" 20	6.90	138.00	Porto Ricos.
" 21	7.155	143.10	Porto Ricos 7.03, Cubas 7.28.
" 23	7.28	145.60	Cubas.
" 26	7.095	141.90	Cubas 7.16, 7.03.
" 27	6.65	133.00	Cubas.
March 1	7.41	148.20	Cubas.
" 2	7.22	144.40	Cubas.
" 8	7.31	146.20	Cubas 7.28, 7.34.
" 12	7.41	148.20	Porto Ricos.

THE HAWAIIAN PLANTERS' RECORD

Volume XXVII. JULY, 1923 Number 3

A quarterly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

Fertilization at Waipio

For several years now the general practice at the Waipio substation has been to use nitrogen only as a fertilizer. This is obtained mainly from nitrate of soda, although ammonium sulphate and ammonium nitrate are also used. We aim to use whichever material is cheaper per unit of nitrogen. We carry on several tests at Waipio where phosphoric acid and potash are applied in addition to the nitrogen. In the last crop one of our tests gave a small response to phosphoric acid. Acting on this indication we are applying phosphoric acid to our young cane.

We use from 280 to 350 pounds of nitrogen per acre, depending upon how old the cane will be when harvested and upon the needs of the field, etc. Short ratoons or short plant get about 280 to 300 pounds per acre; the long crops from 310 to 350. To supply this amount of nitrogen requires from 1800 to 2250 pounds of nitrate of soda or 1350 to 1700 pounds of ammonium sulphate per acre.

We apply the first dose of fertilizer, 50 pounds of nitrogen, from, say, 323 pounds of nitrate of soda per acre to plant cane approximately a month after planting or when the young cane has from two to three leaves. We apply the same amount of fertilizer to ratoons with the first water, say, two or three weeks after the field is harvested, as the young shoots begin to show above ground.

The second dose of fertilizer, twice as much as the first dose, is applied about six weeks after the first one. We have no fixed time for this application, which depends upon the cane. That is, we watch the cane very closely and, as soon as it shows the slightest sign of slower growth or changing color, the fertilizer is applied. The idea is to always keep enough available plant food in the ground to keep the cane growing without check.

The third dose of fertilizer is applied in the same way; the cane is closely watched and as soon as it shows signs of slowing up, the fertilizer is put on. This is usually about 3 months after the second dose. The third application is from 130 to 160 pounds of nitrogen (840 to 1,000 pounds of nitrate of soda).

The cane is now 5 or 6 months old, and for the shorter crops (up to 18 months) has received all its fertilizer. This allows the cane plenty of time to use up the fertilizer and mature before harvest.

In the longer crops, over 18 months, we add an extra dose of 50 pounds of nitrogen, if the cane shows the need of it.

To express briefly what we are attempting to do at Waipio, will say that we watch the cane very closely and, as soon as (or before) the cane gets "hungry" we give it a big feed.

In order to get a quicker indication of a coming check, we have started a system of growth measurements at Waipio. We are measuring a number of cane stalks in each field each week and plot the growth in curves. We believe this will give better and quicker indications of the crop needs than when depending on the eye. Ewa Plantation has been making these measurements for a number of years and has gotten valuable information.

To use this rather large amount of nitrogen, the cane should get regular irrigation. We try to make our rounds in not over 20 days. In the hot summer we try to make it every two weeks. We cannot always do that, but we feel that any longer intervals of irrigation represent a loss.

When we say 50 pounds of nitrogen we mean 325 pounds of nitrate of soda. To make this point clear, the following typical examples of fertilization at Waipio are given for crops of different lengths:

"A" (a 15 months crop)

		Interval between operations
April	25, 1921—Previous crop harvested.	
May	15, 1921—Applied 325 lbs. of nitrate of soda..................	20 days
July	1, 1921— " 650 " " " " "	46 "
October	1, 1921— " 800 " " " " "	92 "
August	1, 1922—Harvest	304 "

"B" (a 20 months crop)

August	15, 1921—Previous crop harvested.	
Sept.	1, 1921—Applied 325 lbs. of nitrate of soda..................	15 days
October	15, 1921— " 800 " " " " "	44 "
February	1, 1922— " 800 " " " " "	108 "
May	1, 1922— " 325 " " " " "	88 "
May	1, 1923—Harvest	365 "

To use such heavy fertilization to advantage, all operations must conform. There must be unusual care in connection with all details.

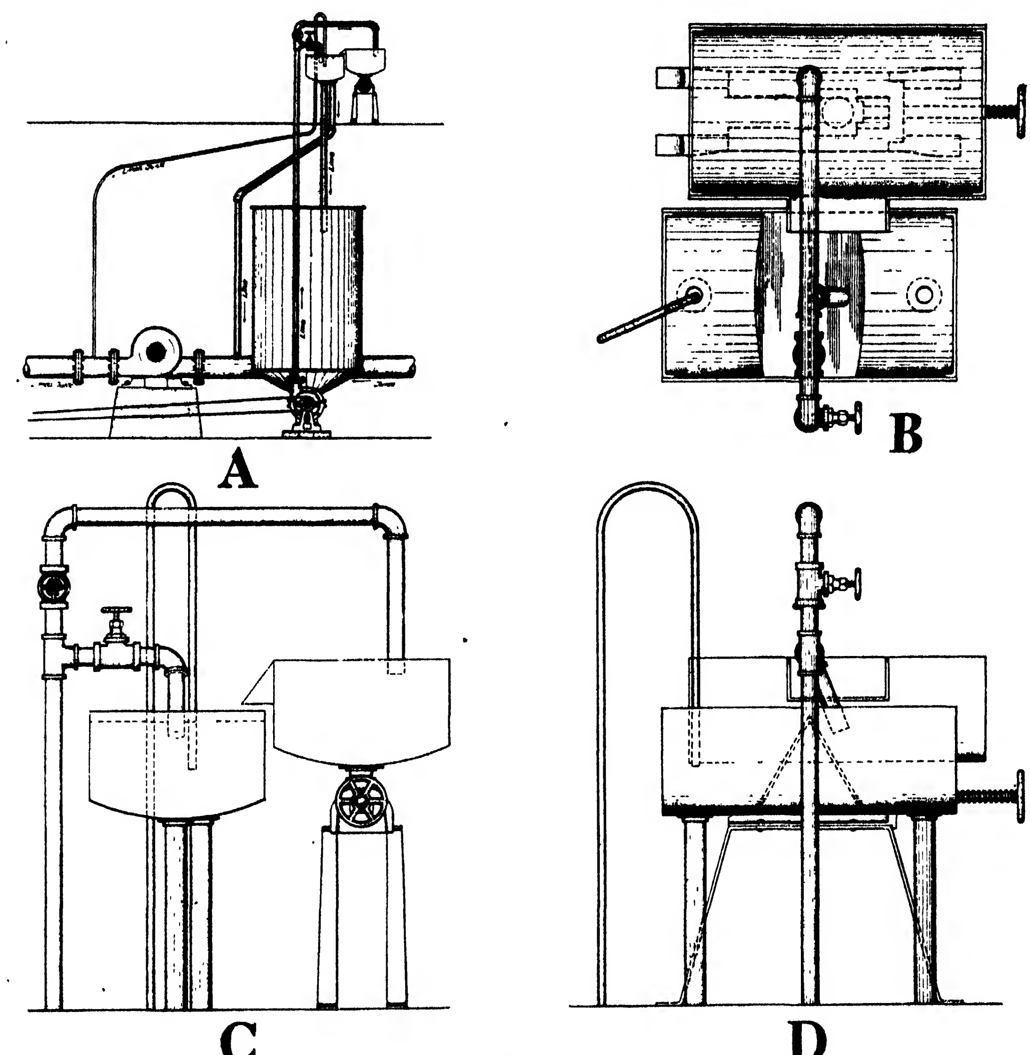
In the absence of information that any areas do not require phosphoric acid and potash, it is better, of course, to apply fertilizer containing these materials.

J. A. V.

A Continuous Juice Liming Device.

By W. R. McAllep.

Through the courtesy of the Oahu Sugar Company we are able to present drawings of an arrangement for continuously liming the mixed juice, designed and installed just prior to the present grinding season.



The Oahu Sugar Co., Ltd.
Waipahu, T. H.
Juice Liming Device

A in the accompanying cut is a sketch of the whole installation showing the mixed juice pump, the pipe for introducing lime milk into the juice on its way from the supply tank under the scales to the pump, the sampling line running back from the pump discharge, the tank for milk of lime, the pump for circulating the lime milk, and the device for regulating the quantity of milk of

lime, continuously added to the juice. *B, C* and *D* are respectively top, end and side views of the latter device.

The regulating device is installed close to the mixed juice scale so that it can be conveniently controlled by the scale man. It consists of two boxes, one stationary and the other movable. The stationary box is divided by a partition shown in *D* and *E*. A pipe leading back to the lime reservoir from one side of this partition returns the surplus milk of lime. The sampling pipe discharges into the other end of the stationary box. A pipe carries the lime and the juice discharged from the sampling pipe from this end of the box into the mixed juice pump suction. The movable box is mounted on an arrangement similar in principle to the cross feed of a lathe. The lime milk enters this movable box and overflows in a broad stream, the outlet shown in the drawing. The partition in the stationary box divides the stream of milk lime, a part being used in the juice and the surplus returned to the lime supply tank. The amount of lime used in the juice is regulated by changing the position of the movable box. A further very close adjustment is made by slightly opening or closing the lower of the two valves shown in *C*, thus changing the amount of lime flowing over the outlet of the movable box. A considerable excess of lime milk above that required for the juice is circulated. This keeps it thoroughly mixed and renders a stirring device in the supply tank unnecessary.

The lime is instantly mixed with the juice in the pump and immediately after altering the adjustment, the juice running from the sampling pipe, which is allowed to run a full stream, shows the exact effect of the change. Waiting for a quantity of lime to mix with a tank of juice, and uncertainty as to whether or not the mixture is complete, and the sample finally secured representative, is entirely avoided.

The operation of this device has been most satisfactory and decided benefits have accrued through its use. As the device is conveniently located, adjustments are easily made and there is no delay between making the adjustment and determining its full effect, the scale man can keep the juice accurately limed to the desired point without difficulty. Though the juice at this factory varies greatly in lime requirement, since this installation has been used, the juice has been kept very evenly limed. The precaution is taken to notify the scale man of a change in cane at the mill.

This installation was moderate in cost, having been made entirely of material on hand. A similar installation could be made in most factories at nominal expense other than for the labor involved and possibly for a pump to circulate the milk of lime. Judging from the much closer control of the clarification secured after using this installation at Oahu Sugar Company, similar installations at other factories would be most desirable.

This system of liming raw juice is novel and letters patent have been applied for in the name of Charles J. Fleener, head sugar boiler for Oahu Sugar Co. Mr. Ernest W. Greene and Mr. W. Richardson, working with Mr. Fleener, contributed largely to making it a success.

The Honolulu Iron Works Company, appreciating the simplicity and efficiency of this improved method of applying lime to sugar juices, have arranged to act as agents for the owners of the rights, and any one desiring further information can obtain it by enquiring of the Honolulu Iron Works Co.

Migration of Aphids.

Observations on the migration of Aphids have recently been made in Europe, which are of interest to us in Hawaii. C. Borner has shown that species of these delicate insects are carried from the German or Dutch coast to the islands of Memmert and Heligoland, distances of fifteen and thirty-nine miles respectively. These insects must be carried out to sea in myriads, as large numbers reached the islands.

These observations are of interest to us as they demonstrate how easy it is for our corn aphid, which carries the Yellow Stripe disease, to scatter over our cane fields, and how the elimination of grasses and corn in and around our cane fields may greatly reduce the Yellow Stripe but will not entirely eliminate it.

F. M.

The National Research Council.*

By Vernon Kellogg.†

The National Research Council is a cooperative organization of scientific men of America, including also a representation of men of affairs interested in engineering and industry and in the fundamental or "pure" science on which the applied science used in these activities depends.

The Council was established by the National Academy of Sciences at the request of the President of the United States, under the Congressional charter of the Academy, to coordinate the research facilities of the country for work on war problems involving scientific knowledge and in 1918, by Executive Order, it was reorganized as a permanent body. Its essential purpose is to promote scientific research and the application and dissemination of scientific knowledge for the benefit of the national strength and well-being.

In the character of its organization and support it differs materially from other similar, and in some cases identically-named organizations which have been established in recent years in several other countries, notably England, Canada, Australia, Japan, Italy and Czecho-Slovakia. These organizations are all Government-supported and to some extent Government-controlled. The American National Research Council, although partly supported during the war period by the government and primarily devoted at that time to activities of direct assist-

* This and subsequent articles on this subject are reprinted from circulars distributed by Council.

† Permanent Secretary of the National Research Council, and Chairman of its Division of Educational Relations.

ance to the government, is now entirely supported from other than governmental sources, and is entirely controlled by its own representatively selected membership and democratically chosen officers. The Council maintains, however, a close cooperation with government scientific bureaus and their activities. It enjoys the formal recognition and active cooperation of about seventy-five major scientific and technical societies of the country, its membership being composed in large part of appointed representatives of these societies.

The Council is composed of a series of major divisions, arranged in two groups. One group comprises seven divisions of science and technology representing, respectively, physics, mathematics, and astronomy; chemistry and chemical technology; biology and agriculture; the medical sciences; psychology and anthropology; geology and geography; and engineering. The other group comprises six divisions of general relations, representing foreign relations, government relations, state relations, educational relations, research extension, and research information. As subordinate or affiliated lesser groups each of these divisions comprises a larger or smaller series of committees, each with its special field or subject of attention. There are certain other committees, administrative and technical, which affiliate directly with the executive board of the Council. The general administrative officers of the Council are a chairman of the executive board, three vice-chairmen, a permanent secretary, a treasurer, and a chairman of each of the various divisions. All of these, except the permanent secretary and the treasurer, are elected annually by the executive board or by the members of the division.

The financial support of the Council is derived, first, from a gift of five million dollars from the Carnegie Corporation of New York, of which a part is to be used for the erection of a suitable building in Washington, now in course of construction, for the housing of the Council and the National Academy of Sciences, and the remainder is to serve as a permanent endowment for the Council; and, second, from other gifts from various sources, mostly made for the specific support of particular Council undertakings. In this latter way the Council has so far received more than two million dollars, one million of which, given by the Rockefeller Foundation ($750,000) and the General Education Board ($250,000), is devoted to the maintenance, through five years, of one series of research fellowships in physics and chemistry and another in medicine. Both the Rockefeller Foundation and the General Education Board have made other gifts to the Council for the support of special scientific projects, while still other gifts have come from numerous donors, including philanthropic foundations, industrial concerns and individuals. The funds, about $200,000, for the purchase of the land on which the Council and Academy building is being erected, were obtained from more than a score of individuals interested in the promotion of the development of science.

The Council maintains two regular series of publications, one called Bulletins, of which nineteen numbers have so far been issued; the other called Reprints and Circulars, of which thirty-six numbers have appeared. In addition it has so far issued 170 miscellaneous publications. The Council also assists both financially and editorially in the publication of the Proceedings of the National Academy of Sciences.

The Council is neither a large operating scientific laboratory nor a repository of large funds to be given away to scattered scientific workers or institutions. It is rather an organization which, while clearly recognizing the unique value of individual work, hopes especially to bring together scattered work and workers and to assist in coordinating in some measure scientific attack in America on large problems in any and all lines of scientific activity, especially perhaps, on those problems which depend for successful solution upon the cooperation of several or many workers and laboratories, either within the realms of a single science or representing different realms in which various parts of a particular problem may lie. It hopes to bring to bear upon scientific problems the wisdom of numbers—where such wisdom is not made unnecessary by the competence of genius. It particularly purposes never to duplicate or in the slightest degree to interfere with work already under way; to such work it only hopes to offer encouragement where needed and support when possible to be given. It hopes to help maintain the morale of devoted but isolated investigators and to stimulate renewed effort among groups willing but halted by obstacles. It will try constantly to encourage the interest of universities and colleges in research and in the training of research workers, so that the inspiration and fitting of American youth for scientific work may never fall so low as to threaten to interrupt the constantly needed output of well-trained and devoted scientific talent in the land. For with any serious interruption in the output of American science and scientific workers, the strength of the nation will be immediately threatened.

The methods of contributing practical assistance to American science which the Council has so far adopted are various, all of them, however, in harmony with the general point of view and policy outlined above. One method is the establishment of special committees of carefully chosen experts for specific scientific subjects or problems urgently needing consideration. These special committees plan modes of attack and undertake, with the assistance of the general administrative officers of the Council, to find men and means for carrying out the plan. Another method is that of bringing together industrial concerns interested in the development of the scientific basis of their processes and inducing them to support the establishment of special investigations under the advice of experts representing the Council. Still another is the stimulation of larger industrial organizations, which may be in the situation to maintain their own independent laboratories, to see the advantage of contributing to the support of pure science in the universities and research institutes for the sake of increasing the scientific knowledge and scientific personnel upon which future progress in applied science absolutely depends. Other methods are the direct maintenance of university research fellowships; the publication of valuable scientific papers for which there is at present no other suitable prompt means of issuance; the preparation of bibliographies and abstracts of current scientific literature; the setting up of well-considered mechanisms for the collection and distribution of information about current research, university and industrial research laboratories and facilities, research personnel, and so forth; and the dissemination, through the press and magazines of popular but authentic scientific news and information for the sake of increasing the public interest in and support of productive scientific work. Still other forms of activi-

ties might be listed, but these mentioned no doubt adequately enough illustrate the Council's methods.

What America needs is not to give up its individual initiative in science, but to add to that initiative means for coordination and organizaton. We need a wider recognition and an increased social evaluation of the place of scientific research in our national life. From these will come a willingness not only to encourage and to support individual scientific effort, but also to insure a greatly augmented productivity of all present research agencies and a much more effective coordination of them with regard both to the planning and the executing of those broad, inclusive scientific investigations which are required for the solution of the problems upon which depend the most effective use of our national resources, the highest production in our agriculture and industry and the maintenance and increase of our national health. In a word, we need more, and better, and better-coordinated science for the preservation and development of our national strength and well-being. The National Research Council is an organization that hopes to contribute in some degree to the meeting of this need.

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Division of Anthropology and Psychology—Raymond Dodge, Professor of Psychology, Wesleyan University, Middletown, Conn.

The Research Information Service of the National Research Council.

What is the Research Information Service?

The Research Information Service is a clearing house for scientific information; a central switchboard which connects you with the persons or materials in which you are interested; a liason service between you and the informational store-houses of this and other countries.

Our country is full of good sources of information. In the east and west, north and south, there are libraries, informational bureaus, associations, industrial concerns and individuals who have compiled valuable data for research workers. The United States Government itself has a great amount of useful information in its scientific departments in Washington.

The difficulty in obtaining scientific information is not *lack of sources*, but *lack of information about sources.*

The Research Information Service Specializes In Sources

The aim of the Service is to furnish useful information about scientific methods and results, and their practical applications in engineering, industry and education. In the furtherance of this aim it has carefully designed and constructed informational apparatus whose value will steadily increase with use. The development of these informational mechanisms and their operation are in charge of a technical staff. This assures intelligent interpretation of requests and skillful search for the information desired.

Informational Mechanisms

To meet specific needs for research data the Service has developed essential apparatus and clearing-house devices. Some important parts of this machinery are listed below:

Research facilities: Funds; Apparatus; Laboratories.
Bibliography of bibliographies: Published; Unpublished.
Biographical Records: Scientists; Technologists.
Topical references: Problems; Projects; Methods; Processes; Results.
Photostatic reproductions: Rare reports; Unpublished data.

What Does Information Cost?

No charge is made for replies to inquiries which do not necessitate a special search for information.

Requests for data which can be secured only by expending considerable time are acknowledged with an estimate of the necessary cost of assembling what is desired. The Service then awaits instructions.

Kinds of Information

Who?—Who knows . . . who has undertaken . . . who can find out . . . who is qualified . . . who is available . . . who has the facilities?

Personnel files: Bibliographic records of American investigators are carefully catalogued. Their specialties are minutely indexed for purposes of classification. A mechanical system is used for selecting names of investigators who have specified research qualifications. Answering requests about current activities is thus simplified.

The Service has innumerable contacts with investigators, their laboratories, interests and present work.

How?

How may an investigator proceed with a research problem; how may he obtain apparatus, or other equipment; how may he apply for supporting funds; how may he find out about methods, processes and technique?

Catalogue and index of apparatus and supplies: A large collection of scientific instrument and supply catalogues and lists has been assembled and indexed for ready reference. This constitutes an excellent source of information about types, availability and prices of equipment for research.

File of research funds: Medals, prizes, grants, fellowships and scholarships for the encouragement or support of research are listed in the Information Service. Is there a better place to seek knowledge of funds for research?

What?

What research is in progress; what is projected; what reports are published; what specific lists or bibliographies are available?

Central reference file: References to information about all kinds of scientific problems, methods, and results are systematically made. A classification skeleton has been adopted which can be expanded to provide, if necessary, for several millions of reference topics.

Surveys of bibliographies: Bibliographies on numerous scientific and technical subjects have been listed. For several of the natural sciences lists of published and of unpublished bibliographies are being compiled by competent persons either for use in the files of the Research Information Service, for publication, or both.

Indexes and abstract journals: Abstracts and indexes of publications are at hand for use as sources of information about reports of research.

Resources of Libraries: Library facilities and equipment in every part of the country are known. They often are cited to isolated investigators.

Publication of compilations: When compilations of information are such as to be widely useful they are published either in the Bulletin or the Reprint and Circular Series of the National Research Council.

Where?

Where is a certain kind of laboratory; where may specific problems be submitted for solution; where may supporting funds be obtained; where can an obscure journal or periodical be found; where are the people who are interested in given problems?

File of industrial laboratories: As a directory to sources of research work this compilation has proved particularly useful. It gives pertinent information about laboratories and special facilities for research.

List of serials and periodicals: Information about thousands of serials located in Washington libraries has been assembled. With such a working list the staff can quickly turn to the proper library sources for desired literature.

At Your Service

The technical staff can call upon members of the Research Council for advice or assistance. Representative as it is of sixty-six of the major scientific and engineering societies of the country, the Council, through its various divisions and committees, has wide and important contacts. It is in touch with research activities in educational, industrial and governmental institutions and with current work and projects in mathematics, physics, astronomy, chemistry, geology, geography, zoology, botany, physiology, psychology, anthropology, agriculture, medicine and engineering.

This cooperative aid is at the service of those interested in the advancement of science and technology.

TYPICAL REQUESTS

(Requests should be clear and specific.)

1. Where may oelic, linolic, and certain other acids be procured?
2. Information as to occurrence of boron in plants and animals.
3. Names of ferns that can furnish calcium silicate.
4. The solubility and toxicity of para-dichloro-benzene.
5. Reference to studies of acquired resistance to tuberculosis, diphtheria, and inheritance of resistance.
6. Status of knowledge on biological effects of use and disuse.
7. Where may colored slides representing types of edible and non-edible mushrooms be obtained?
8. Mortality rates of French Canadians in this country and in Canada.
9. What is known about the chemical composition of the gastric crypts of the stomach mucosa?
10. How may growth of yeast be stimulated?
11. Studies on the gastro-intestinal tract of the turtle.
12. Brashear formula for silvering glass.
13. Information on the manufacture and testing of writing ink.
14. Where may powdered shellac be purchased?
15. Reference to investigations on methods of making peat fuel.
16. Information about smoke prevention.
17. Verification of the following reference: Ranke, J. Tetanus—Eine physiologische Studie. Leipsic. 1865.
18. Desired: a photostat copy of a certain scientific article.
19. Bibliography: Waterproofing of cement and concrete.
20. Bibliography on "Absorption spectra of inorganic compounds."
21. Where may Braun tube for A. C. work be obtained?
22. Desired: plans of buildings constructed by universities for departments of science.
23. Where may Nernst Lamp glowers be obtained?
24. Desired: name of firm for quartz blowing.
25. Information about instrument devised to measure ductility of pasty materials such as grease or dough.
26. Names of specialists studying the control of cotton boll weevil and other insect enemies of cotton plant.
27. A list of the deans of engineering schools.
28. List of psychologists concerned with psychology of music.
29. List of suitable candidates for assistant professorship of biology.
30. List of the outstanding women in science from 1850 on.
31. Recent books on the characteristics and distribution of the races of Europe.
32. Where may Army Mental Tests be obtained?
33. The Negro in science, invention, education, art and literature.
34. A list of the industrial organizations interested in the use of psychological tests.
35. Bibliography on latent effects of mustard gas poisoning.
36. Assistance in securing Stenquist test of mechanical ability.

Special Announcement to American Chemists and Engineers.

You Are Invited to Use Research Information Service of the National Research Council.

RESOURCES

STAFF OF SPECIALISTS

Chemistry and chemical engineering are well represented on the technical staff of the Research Information Service. The following at present are resident members of the staff of the National Research Council and available for assistance to the Information Service:

E. W. Washburn, Chairman, Division of Chemistry and Chemical Technology.
Clarence J. West, Secretary, Division of Chemistry and Chemical Technology.
H. F. Whittaker, Scientific Associate, Research Information Service.

PERSONNEL FILES

Essential information about research chemists and chemical engineers in the United States is found in the personnel catalogue of the Information Service. This file has been translated into mechanical form so that information about persons may be obtained quickly by a process of mechanical sorting. By this method desired information may be readily obtained about persons eligible for certain tasks or appointments, or about research facilities, scientific resources, prevailing interests, and current work.

BIBLIOGRAPHIES IN CHEMISTRY AND ENGINEERING

The Service is developing a catalogue of published and unpublished bibliographies in chemistry and chemical engineering. You are welcome to any bibliographical information we have. If we do not have what you need, we shall gladly try to locate it for you. For the promotion of research interests, we earnestly solicit from all investigators reports which will make our bibliographic records more complete.

SCIENTIFIC APPARATUS AND RESEARCH CHEMICALS

A file now containing more than 500 catalogues of manufacturers and dealers in scientific instruments is maintained. Information about sources, availability and loan of apparatus and equipment is thus accessible. A compilation showing the manufacturers of research chemicals has also been made for use especially in referring to the rarer products.

RESEARCH SUBSIDIES

The Service maintains current information about available fellowships, scholarships, grants, prizes, and funds used for encouraging scientific research in the United States.

CURRENT WORK

The Service has numerous and important contacts with investigators, laboratories and other research interests. Non-confidential data about research in progress will be supplied on request. If you wish to have contacts with investigators working on problems similar or related to yours, we shall be glad to give you every aid possible.

COST

No charge is made for replies to inquiries which do not necessitate special search for information or special expenditure for preparation of our report. In other cases requests are acknowledged with an estimate of the necessary cost of assembling what is desired. The Service then awaits instructions. Nominal charges are made for time involved in special searches and for photostats of rare reports.

SAMPLE REQUESTS

1. Personnel. 3255 (November 17, 1922): A list of women who have received a Ph.D. degree in organic chemistry.

2. Bibliography. 1196 (October 10, 1921): Literature references dealing with high temperature experiments with carbon leading to its crystallization for the production of artificial diamonds.

3. Design. 2839 (July 31, 1922): Design of automatic thermostatic regulator for automobile radiator and recommendation of liquid to be used in it.

4. Apparatus. 155 (December 11, 1920): Where may a special type of spectrometer be obtained? (Above apparatus was described in a technical paper.) 3050 (October 11, 1922): What companies manufacture or sell hydrometers for determination of the specific gravity of liquids ranging between 2.00 and 3.33?

5. Process. 3138 (October 28, 1922): Request for information on the commercial dehydration of fruits and vegetables.

REPETITION OF REQUESTS

Correspondents occasionally apologize for the frequent use they make of the Service. This attitude is the result of incomplete understanding of the purpose of our organization. The Research Information Service is maintained to promote science and its applications. The extent to which the investment is justified is measured by the use that is made of it. The more it is used, the more valuable it can become.

Special Announcement to American Biologists

Concerning the Research Information Service of the National Research Council.

RESOURCES

STAFF OF SPECIALISTS

Biology is well represented on the technical staff of the Research Information Service. A Scientific Associate, serving jointly as Executive Secretary of the Division of Biology and Agriculture, and a Technical Assistant are immediately available. The Service also has for consultation the membership of the Division of Biology and Agriculture and the chairmen of other divisions of the Council having related interests.

BIBLIOGRAPHIES

In catalogues of manuscript bibliographies the Service has important references to unpublished compilations on biological subjects which supplement importantly existing abstracts and indexes. These unpublished sources are useful where recent information is desired. Bibliographic records are in charge of an experienced librarian and classification specialist who coordinates the various resources of the Council for effective response to each inquiry.

LIBRARY DISTRIBUTION OF PERIODICALS

Compilations have been made of union and special library lists for use in advising investigators where particular periodicals may be obtained. Information can be furnished about the availability of serial publications in the principal domestic libraries.

PERSONNEL FILES

Valuable information about investigators in the biological sciences is available in the personnel catalogue of the Research Information Service. This alphabetical catalogue is supplemented by a mechanical file which will shortly be in operation for investigators in plant and animal biology and agriculture. With this organization of personnel information the Service can refer to persons qualified for stated needs as indicated by research facilities, scientific resources, prevailing interests, current work, etc. The personnel mechanism related to the records of psychologists has been described in Bulletin No. 22 of the National Research Council.

RESEARCH SUBSIDIES

The Service maintains current information about available fellowships, scholarships, grants, prizes, and funds used for encouraging scientific research in the United States. The maintenance of this information is greatly facilitated by wide and varied contacts with investigators and research agencies.

SCIENTIFIC APPARATUS AND RESEARCH CHEMICALS

A file now containing more than 500 catalogues of manufacturers and dealers in scientific instruments is maintained. Information about sources, availability, and loan of apparatus and equipment is thus available. A compilation showing the accessibility of research chemicals has also been made for use especially in referring to manufacturers of the rarer products.

SAMPLE REQUESTS

1. Bibliography: Existing bibliographies on the subject of plant growth in relation to climate with particular reference to corn and sunflowers in relation to sunshine, precipitation, evaporation, temperature, etc.

2. Personnel: (1) A list of young zoologists interested in embryology and invertebrate morphology. (2) The percentage of women engaged in botanical research.

3. Funds: A grant of two hundred dollars to purchase apochromatic optical equipment for the study of chromosome dimensions.

4. Equipment: A motion picture film on "Mitosis."

COPIES OF ORIGINAL SOURCES

With photostatic equipment the Service can furnish copies of rare reports or publications which are available in the numerous libraries of the District of Columbia. Such copies are furnished at twenty-five cents per sheet.

COST

No charge is made for replies to inquiries which do not necessitate special search or expenditure. Requests which demand considerable expenditure are acknowledged with an estimate of the necessary cost. The Service then awaits instructions.

It often happens that expensive information has previously been compiled. Multiplication of requests, therefore, tends towards increased economy in the Service. Appeal for assistance in the interest of science and technology as often as needed is earnestly invited.

Cultivation Experiments in the Hilo District.

By J. A. Verrett

Hilo Sugar Co., Exp. 14, Hilling.
Hilo Sugar Co., Exp. 15, Surface Hilling.
Hilo Sugar Co., Exp. 16, Off-Barring.

In this series of tests, various cultivation practices were compared. These included off-barring, hilling and plowing. Three crops have now been harvested during a period of six years.

The experiments were located in field 22, Hilo Sugar Co., at an elevation of five or six hundred feet. The cane was Yellow Caledonia, second, third and fourth ratoons.

Fertilization was uniform to all plots and according to plantation practice. There were nine to ten repetitions of each treatment.

The results from three crops show that off-barring lowered the yield of sugar. Hilling produced the same results. Surface cultivation produced more sugar than where plows were used.

These results indicate that weed control should be accomplished with the least possible disturbance to the root system of the growing cane. If the soil conditions are such that it is necessary to use plows, this should be done as early as possible before the root system of the young ratoons has become established. Even then, one must know that there is some check, as, until the new shoots have root systems of their own, they feed to some extent through the old root system by way of the old stumps.

In cases where the soil packs very hard it may be necessary to off-bar in order to have loose soil for surface cultivation later, in weed control. Otherwise, one would have to plow in the weeds. We believe it is better to off-bar early than to have to plow close to the cane later.

The cultivation of young cane can be expressed in a basic way as follows:

Control weeds in the most efficient way with the least possible disturbance to the root system of the growing cane. No one system can be the best all the time. The methods to use will vary with the time of year, the amount and cost of labor, etc.

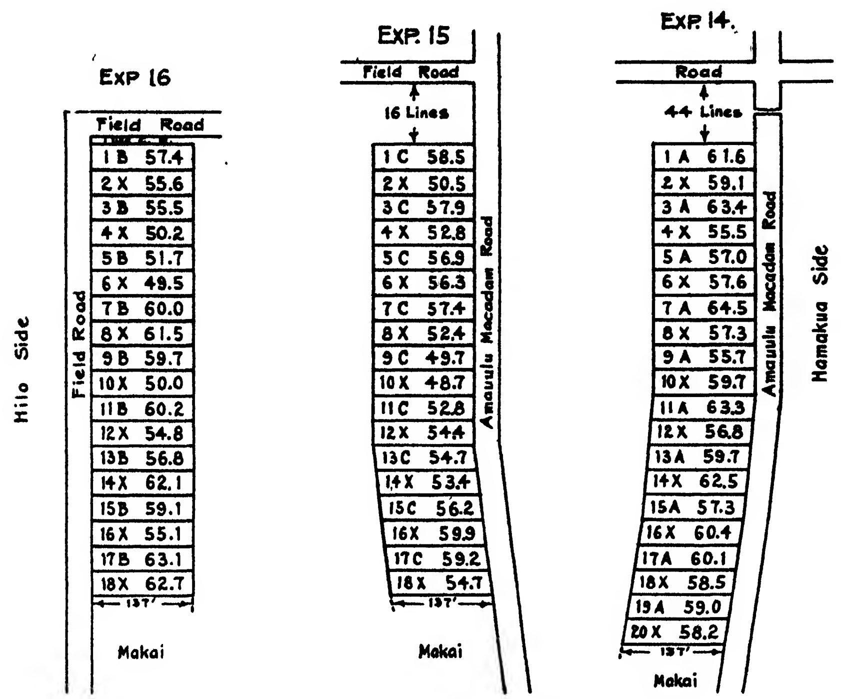
Hilo Cultivation Experiments

Exp. 14 Hilling - An Average Of 1919, 1921 & 1923 Crops

Exp. 15 Surface Cultivation-An Average Of 1919 & 1923 Crops

Exp. 16 Offbarring - An Average Of 1919, 1921 & 1923 Crops

Field 22



EXPERIMENT 14—HILLING

This test comprised a total of twenty plots, each one-tenth of an acre in size and consisting of six lines. The two outside lines of each plot were discarded at harvest and the four middle lines only used as experimental cane. Every other plot was hilled, the alternate ones were not. In all other respects all plots received identical treatments.

The results obtained from three crops are summarized as follows:

Treatment.	Tons of Cane per Acre. 1919 Crop.	1921 Crop.	1923 Crop	Average Q. R.	Average Tons Sugar per Acre.
Not hilled	60.9	68.4	51.2	7.75	7.77
Hilled	57.0	66.8	51.9	7.88	7.44

In the following table are given the maximum and minimum plot yields of cane for each series of plots for each crop.

Treatment.	Tons of Cane per Acre. 1919 Crop. Max.	1919 Crop. Min.	1921 Crop. Max.	1921 Crop. Min.	1923 Crop. Max.	1923 Crop. Min.
Not hilled	66.9	55.4	77.2	64.0	58.9	45.6
Hilled	65.2	51.2	77.3	56.2	55.8	45.2

From the above table we see that in two out of three crops the maximum yield was obtained from the not-hilled plots, while in two crops out of three the lowest yields were from hilled plots.

Details of Experiment

Object:

To compare hilling with no hilling.

Location:

Hilo Sugar Company, Field 22, along Hilo side of Amauulu macadam road.

Crop:

Yellow Caledonia, fourth ratoons.

Layout:

Number of plots, 20. Size of plots, 1/10 acre each, consisting of 6 lines, each 5.3' wide by 137' long. Lines 1 and 6 of each plot are guard lines.

Plan:

A plots (odd) not hilled up, otherwise regular cultivation practice.
X plots (even) hilled.
Fertilization—Uniform by the plantation.
Experiment planned in 1917 by L. D. Larsen.
Experiment laid out in 1917 by W. P. Alexander.

EXPERIMENT 15—OFF-BARRING, HILLING, ETC., VS. SURFACE IMPLEMENTS AND HOES ONLY.

This test comprised eighteen plots, nine for each treatment. Each plot was one-tenth acre, consisting of six lines. In figuring the results, the four middle lines only were used, the two outside ones being discarded. The fertilization was uniform to all plots and followed plantation practice.

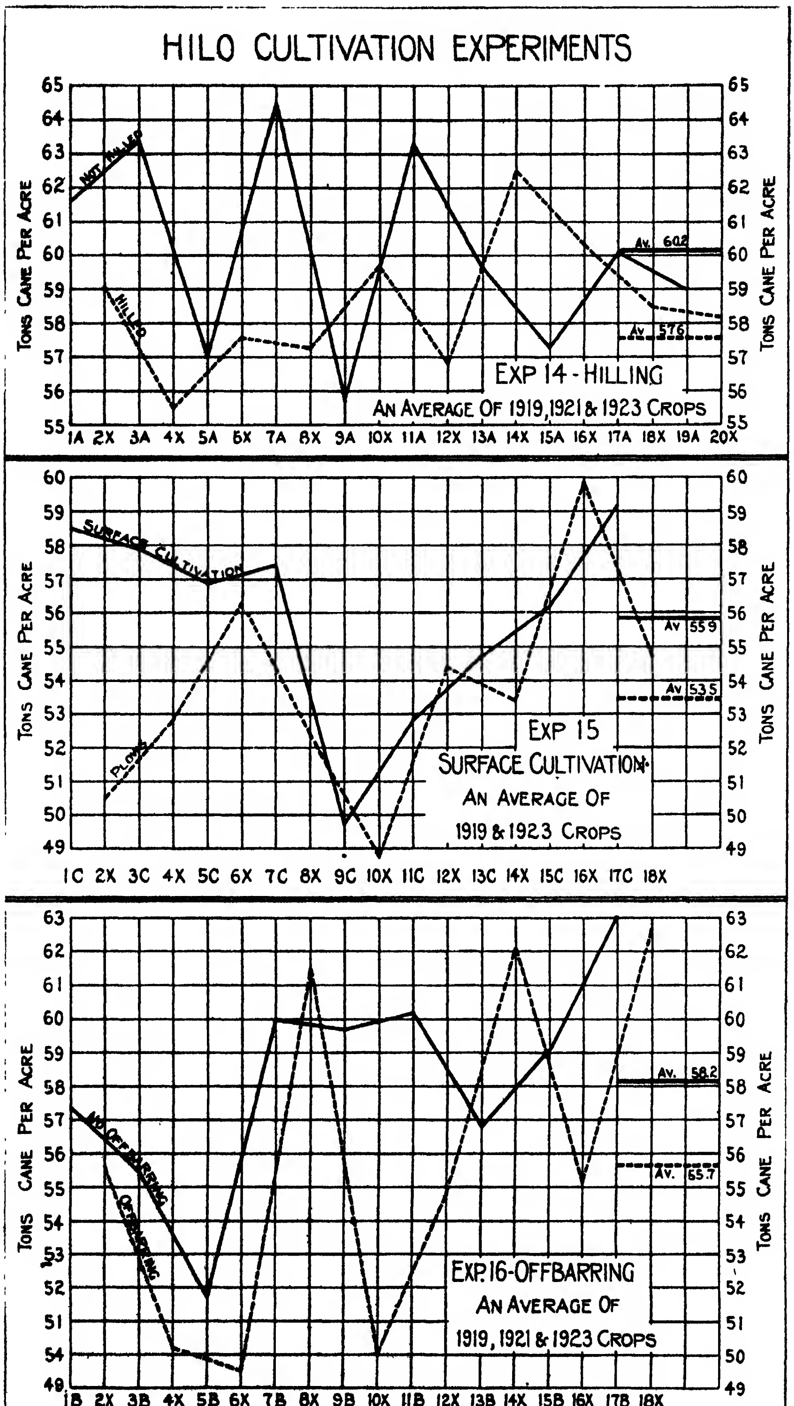
Owing to mistakes in cultivation, due to over-running of plots in plowing, this area was not harvested as an experiment in 1921.

The results obtained from two crops are given as follows:

Treatment.	Tons Cane per Acre. 1919 Crop.	1923 Crop.	Average Q. R.	Average Tons Sugar per Acre.
Not off-barred or hilled, etc......	56.2	55.4	7.99	6.98
Off-barred and hilled, etc........	55.6	51.7	8.02	6.70

The maximum and minimum plot yields for the different treatments were as follows:

Treatment.	Tons of Cane per Acre. 1919 Crop. Max.	Min.	1923 Crop. Max.	Min.
Not off-barred or hilled, etc.............	59.9	49.2	62.5	50.1
Off-barred, hilled, etc.................	60.0	48.4	53.0	46.0


HILO CULTIVATION EXPERIMENTS
TONS CANE PER ACRE
NOT HILLED
HILLED
AV. 60.2
AV. 57.6
EXP 14 - HILLING
AN AVERAGE OF 1919, 1921 & 1923 CROPS
1A 2X 3A 4X 5A 6X 7A 8X 9A 10X 11A 12X 13A 14X 15A 16X 17A 18X 19A 20X
SURFACE CULTIVATION
PLOWS
AV 55.9
AV 53.5
EXP 15
SURFACE CULTIVATION
AN AVERAGE OF
1919 & 1923 CROPS
1C 2X 3C 4X 5C 6X 7C 8X 9C 10X 11C 12X 13C 14X 15C 16X 17C 18X
NO OFFBARRING
OFFBARRING
AV. 58.2
AV. 55.7
EXP. 16-OFFBARRING
AN AVERAGE OF
1919, 1921 & 1923 CROPS
1B 2X 3B 4X 5B 6X 7B 8X 9B 10X 11B 12X 13B 14X 15B 16X 17B 18X

Details of Experiment

CULTIVATION EXPERIMENT—REGULAR PLANTATION PRACTICE VS. CULTIVATION FOR WEED CONTROL ONLY.

Object:

To determine the value of ordinary cultivation, including off-barring, small plowing and hilling, against cultivation for weed control only.

Location:

Hilo Sugar Co. Field 22, on the Hilo side of the Amauulu macadam road.

Crop:

Yellow Caledonia, fourth ratoons.

Layout:

Number of plots, 18; area of plots, 1/10 acre. Each plot consists of 6 lines 5.3′ wide and 137′ long. Lines 1 and 6 of each plot to be used as guard lines.

Plan:

C plots (odd) after palipali-ing, no off-barring, plowing nor hilling; weeds controlled by hoeing and light cultivation.

X plots (even) have ordinary plantation cultivation, including off-barring, hilling, etc.

Fertilization—Uniform by the plantation.

Experiment planned in 1917 by L. D. Larsen.

Experiment laid out in 1917 by W. P. Alexander.

EXPERIMENT 16—OFF-BARRING.

This test consisted of eighteen plots, each one-tenth acre, composed of six lines each. The two outside lines of each plot were guard rows and not harvested as part of the experiment.

Nine plots were off-barred and nine alternating plots were not. All other work and the fertilization were identical to all plots.

As in the two experiments just reported, we find that the more plowing, the less sugar.

The results obtained from three crops follow:

Treatment.	Tons of Cane per Acre. 1919 Crop	1921 Crop	1923 Crop	Average Q. R.	Average Tons Sugar per Acre.
Not off-barred	59.4	62.0	53.0	8.04	7.23
Off-barred	57.1	60.7	49.3	8.28	6.73

The maximum and minimum yields obtained from the different plots for the three crops were as follows:

Treatment.	Tons of Cane per Acre. 1919 Crop. Max.	1919 Crop. Min.	1921 Crop. Max.	1921 Crop. Min.	1923 Crop. Max.	1923 Crop. Min.
Not off-barred	63.5	55.1	68.1	52.1	59.9	43.4
Off-barred	63.2	52.1	63.5	51.9	59.5	36.8

In this test, in all three crops, the highest yields were from plots which were not off-barred and the lowest were from plots which were.

A rather interesting thing in regard to these experiments is the fact that in all three of them the plots which had the least plowing had the better juices. We do not know why this should be unless it is due to the fact that in plowing, the cane roots were cut, thereby causing the plants to put out new root systems, and that these, being young, kept the cane greener than was the case where the original root system was not cut.

Details of Experiment

Object:

To determine the value of off-barring and subsoiling ratoons.

Location:

Hilo Sugar Co. Field 22, on field path off Amauulu road.

Crop:

Yellow Caledonia, fourth ratoons.

Layout:

Number of plots, 18; area of plots, 1/10 acre, consisting of 6 lines each 5.3′ wide and 137′ long.

Plan:

B plots (odd) not off-barred and subsoiled after palipali-ing; otherwise regular plantation practice of hilling, etc.

X plots (even) regular plantation practice, including off-barring, subsoiling, hilling, etc.

Fertilization—Uniform by the plantation.

Experiment planned in 1917 by L. D. Larsen.

Experiment laid out in 1917 by W. P. Alexander.

The Effect of Fertilizers Containing Borax Upon the Growth of Sugar Cane.

By G. R. Stewart

Previous to the late war, compounds of the element Boron, of which boric acid and borax are the best known, had received very little attention in practical agriculture. It had been known for many years that at least traces of Boron were contained in most soils and that numerous plants absorbed minute quantities of this element. Boron had been found in a variety of fruits such as apples, pears, cherries, raspberries, figs, and in grapes and hops. Owing to its occurrence in the two latter products, traces of Boron have been frequently reported in wines and beers.

These early studies included much work on the effect of compounds of Boron upon cultivated plants grown in water cultures. A number of investigators reported some stimulating effect from very small concentrations of borax or boric acid. Stimulation has been commonly reported from minute quantities of manganese compounds, but many investigators are inclined to class managnese as an

essential element in the growth of plants. Larger amounts of borax were found to be notably toxic to practically all cultivated plants. These early experiments on Boron are excellently summarized by Brenchley (2).

When potash supplies from Germany were cut off by the war, all other sources of this plant food were developed. One of these emergency sources was potash nitrate obtained from the mother liquors of commercial sodium nitrate in Chile, and another was from the brines of Searles Lake. The potash from both these regions at times contained appreciable quantities of borax.

Owing to the widespread occurrence of borates in soil and plants it was not believed that the presence of this mineral in fertilizers would have any harmful effects. Cook (4) of the U.S. Department of Agriculture had previously used borax as a larvacide to prevent flies in manure. He applied this borax-treated manure to a variety of crops, adding amounts of borax in this way equivalent to 30.8 pounds, 46.2 pounds and 77 pounds of boric acid per acre. The effect varied with the crop to which the manure was applied, but in general it was concluded that the smallest applications of borax were safe for most crops.

Conner (3) of Indiana first reported serious borax injury to field crops from the application of fertilizers containing borax. He found definite injury to corn from as little as two pounds of borax per acre. The fertilizer containing this borax was applied in the seed drill so that the borax had an excellent opportunity to come into close contact with the young seedlings.

About this time reports reached the U.S. Department of Agricuture that extensive injury had occurred on many hundreds of acres of potatoes in Maine, and upon cotton, corn and tobacco crops in the South. This injury was traced to fertilizers that contained borates. Later experiments by Morse (6) in Maine, Jenkins (5)in Connecticut, Blair (1) and Brown in New Jersey, Neller (7) in Vermont, and Plummer (8) and Wolf in North Carolina all showed that borax was harmful to a great variety of crops, even in amounts as small as five pounds of borax per acre. As a result of this extensive experimental work, it was decided by the U.S. Bureau of Soils that two pounds of borax per acre was as much as could be applied to most field crops with any degree of safety.

Here in the Hawaiian Islands some interest arose in this problem, owing to the fact that potash nitrate, obtained from the mother liquors of the sodium nitrate industry, was being imported. Certain lots of this potash nitrate contained traces of borax, while shipments were occasionally offered to the dealers at a considerably reduced rate when appreciable percentages of borax were present. Since such notable harm occurred upon most field crops on the mainland when treated with fertilizers containing borax, it was very desirable to know the effect of borates upon sugar cane. It was quite possible that even minute traces might be harmful. Should the cane plant be shown to stand borax in appreciable amounts, there was the possibility that a saving might be effected by purchasing potash nitrate which contained borax.

A preliminary experiment as to the effect of borax upon cane was conducted by R. M. Allen at the Waipio substation of this Experiment Station. The variety of cane used was H109. Single stools were grown ~~in small~~ soy tubs holding 33 pounds of soil. The borax was applied in amounts equal to 10, 30, 60, 120, 240 and 580 pounds of anhydrous borax per acre. After one month's growth no

definite injury was noticeable upon any of the tubs, so the applications upon the 10- and 30-pound treatments were increased to 2,640 pounds and 5,280 pounds of anhydrous borax per acre. After another month the cane in the tubs receiving these heavy applications showed a distinct evidence of leaf-spot and burning from the borax. Some slight signs of injury were also noted upon the 580-pound treatment tubs.

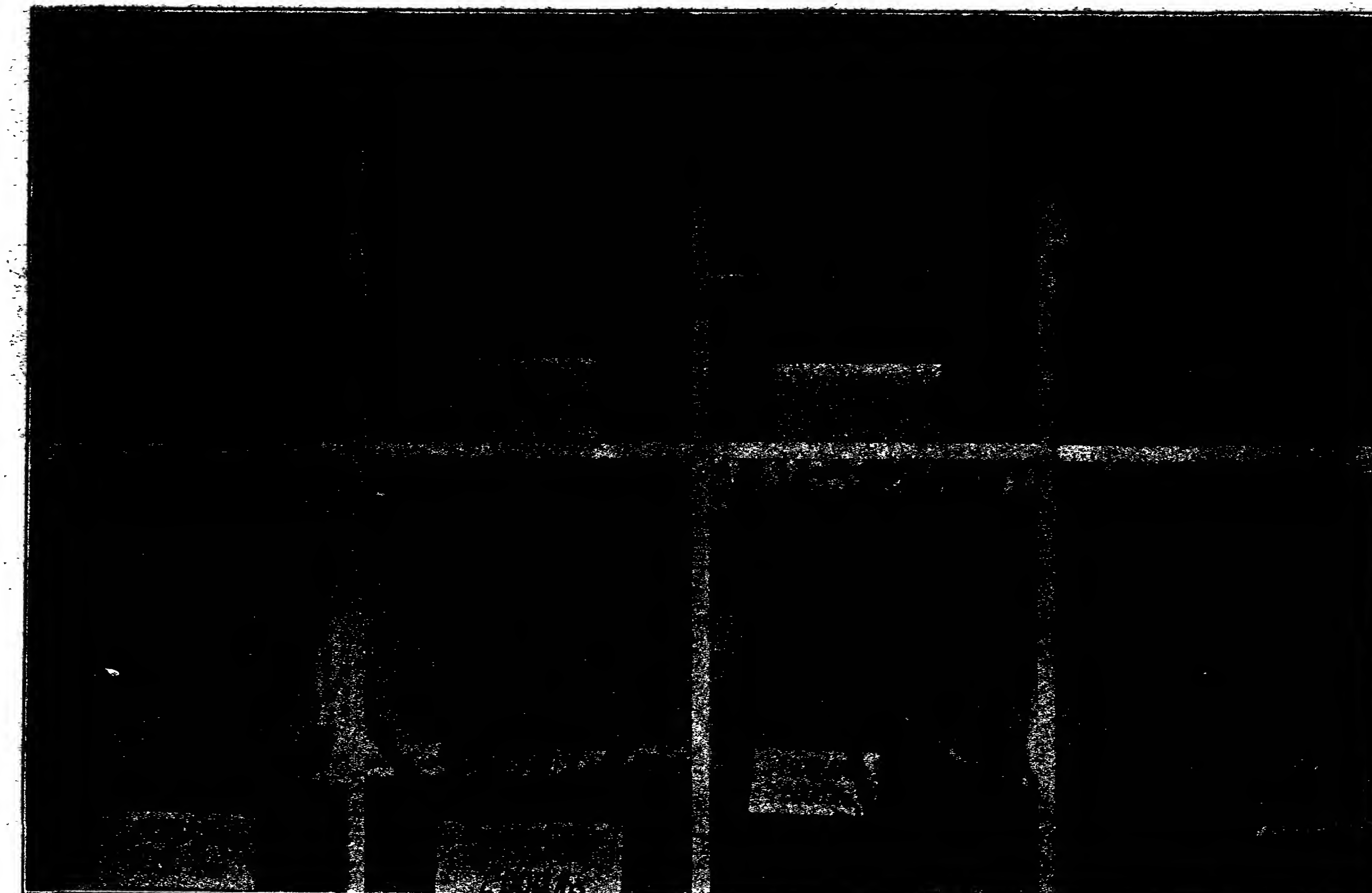
This experiment in small wooden tubs suffered from several difficulties. It was hard to keep the tubs at a uniform moisture content as the soil dried out rapidly around the edges and shrank away from the side of the container. The irrigating water then ran over the outside of the block of soil without wetting the center of the pot. It was consequently hard to keep even the untreated plants in perfectly thrifty growing condition. The volume of soil contained in the tubs was also so small that shortly after the first signs of injury appeared it was evident that all the plants were rootbound and suffering for lack of space. After this point it was difficult to estimate the injury due to borax and that due to crowding the roots. It was also impossible to tell how much of the borax was leached out of the soil by the heavy watering which became necessary to try and moisten the soil completely.

A later experiment has therefore been conducted by the writer. This was intended as a preliminary study to be followed later by more detailed work. It was desirable to find, first, something as to the limits of tolerance of cane for borates and also to obtain some exact information as to the retention of borates in the soil.

In this study the cane was grown in large concrete pots two feet wide, two feet deep and two feet high, holding approximately 540 pounds of soil. Previous work with containers of this type had shown that fairly normal cane could be grown in them to an age of four to six months. H109 cane was used. Three-eye cuttings, with two eyes pinched out, were started in small nursery boxes and grown until about three weeks of age. Plants of uniform size were then selected and planted in the concrete boxes. About a week after these single eye stools were set out they were well established. They were then fertilized with a uniform application of nitrate of soda at the rate of 1,000 pounds per acre. Borax was added in seven amounts to equal 50 pounds, 250 pounds, 500 pounds, 1,000 pounds, 2,000 pounds, 4,000 pounds and 8,000 pounds of anhydrous borax per acre.

At the end of the first month's growth the containers receiving 4,000 and 8,000 pounds of borax per acre began to show visible signs of injury. This became more acute as time went on and these stools of cane were noticeably stunted but not entirely killed. There were some slight signs of injury to the leaves of the cane receiving borax at the rate of 1,000 and 2,000 pounds per acre, but no visible evidences of harm appeared on the cane receiving the smaller treatments.

The containers were all irrigated with sufficient frequency to keep the soil close to the optimum moisture content. All surplus drainage water was caught in large bottles and periodically analyzed for borax. For the first four months of the cane's growth no borax was leached out of any of the containers. The crop



A deleterious effect of borax on sugar cane growth is not plainly evident to the eye, except in applications of 4,000 pounds or more to the acre. The cane weights shown elsewhere would indicate that smaller quantities are injurious, although there is a possibility that very small applications act as a stimulant to cane growth.

was harvested at nine months of age. By that time the amounts shown in the following table had been leached out:

Borax Applied per Acre.	Borax Leached Out of Soil, Grams.	Amounts Removed Calculated to Acre Basis, Lbs.
1—Blank	None	None
2— 50 Pounds....................	Trace	Trace
3— 250 "	Trace	Trace
4— 500 "	9.35	8.8
5—1,000 "	1.77	44.9
6—2,000 "	5.78	146.7
7—4,000 "	16.56	420.4
8—8,000 "	48.23	1224.0

It will be seen that by far the largest part of the borax has been retained in the soil. With the heaviest treatment, slightly over 15 per cent of the borax applied has been leached out.

The harvesting results are given in the following table. As it is a preliminary experiment without duplicates, no close deductions should be drawn from small differences in yield. It is believed, we may safely state, that the cane plant is not particularly sensitive to borates as all the lower treatments have produced practically as good crops as the untreated blank. The smallest treatment at the rate of 50 pounds per acre may even show some evidence of stimulation. Here, again, definite conclusions will be reserved until further work has been carried out with the necessary duplication of treatments.

HARVESTING RESULTS

Treatment Lbs. Borax per Acre.	Weight of Cane. Pounds.	Weight of Tops. Pounds.	Total Weight Pounds.
Blank	7.0	4.0	11.0
50	10.0	4.5	14.50
250	6.5	3.75	10.25
500	6.5	3.50	10.00
1000	6.0	2.50	8.50
2000	7.5	3.50	11.00
4000	2.5	1.75	4.25
8000	1.0	.50	1.50

The results so far obtained confirm those of Allen, in showing that small amounts of borax are not appreciably harmful to the cane plant. The large proportion of this salt retained in the soil would warrant considerable caution in applying fertilizers with borax continuously to cane land. Further work is planned to learn more about the effect of continuous applications of fertilizers containing small amounts of borax.

The accompanying illustrations show the type of growth obtained with some of the typical treatments. The photographs were taken just before the cane was harvested.

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Experiments at Lihue Plantation Co.

By J. A. Verret.

Exp. 1, Phosphoric Acid, 1921 and 1923 Crops.
Exp. 2, Phosphoric Acid and Potash, 1921 and 1923 Crops.
Exp. 3, Forms of Nitrogen.

Two crops have now been harvested from this series of experiments, one plant and one ratoon. The cane is Yellow Caledonia. Previous to planting, the field was fallowed for one year. The trash from the previous crop was plowed in and stock was pastured on the field during the period of fallow.

The plant cane was cut back early in July, 1919, and harvested April 22, 1921. The ratoon crop was not cut back and was harvested March 5, 1923.

The results of the tests show no response at all to potash. Phosphoric acid showed some indications of crop increases, but these increases were too small to be profitable.

Equal amounts of nitrogen from nitrate of soda and from dried blood produced equal results. Applying all the fertilizer the first year produced better juices.

Lihue Experiment No. 1, Phosphoric Acid

Reverted phosphate was applied at the rate of 1,000 pounds per acre to all phosphate plots, but to the plant crop only. The ratoons received no phosphate. Eighteen plots received reverted phosphate. To nine of these, the phosphate was broadcasted before furrowing, to the other nine plots the phosphate was applied in the furrow before planting.

All plots in both crops received uniform nitrogen fertilization from nitrate of soda. In addition to the nitrate, 500 pounds per acre of molasses ash was applied to all plots in the plant crop.

The results obtained from the two crops are tabulated as follows:

Treatment	Tons Cane per Acre. 1921 Crop.	Tons Cane per Acre. 1923 Crop.	Average Q. R.	Average Tons of Sugar per Acre.
Not Reverted Phos.	42.0	31.4	8.66	4.24
1,000 lbs. Reverted Phos. broadcast	44.6	31.1	9.01	4.21
1,000 lbs. Reverted Phos. in furrow	42.3	35.3	8.90	4.36
Av. all Phos. plots	43.4	33.2	8.95	4.28

The results obtained here are within experimental error and indicate no profitable return from the phosphoric acid used. Results of the same nature were obtained on similar soils at Grove Farm. This was in contrast to results from mauka fields where good gains were had from phosphate applications.

Details of Experiment

Reverted Phosphate—Residual Effect

Object:

Too determine the residual effect of reverted phosphate on makai land at Lihue plantation.

Location:

Field 1.

Crop:

Yellow Caledonia cane, first ratoons. Previous crop harvested April, 1921. This crop not to be cut back.

Layout:

No. of plots, 33. Size of plots, 1/10 acre, 108′ long by 40.3′ wide; comprising 24 straight lines, 40.3′ long x 4½′ wide.

Plan:

Plots	No. of Plots	Treatment
A	9	1,000 lbs. reverted to plant crop—broadcast
B	9	1,000 lbs. reverted to plant crop—with seed
C	8	No reverted phosphate

All plots to receive 484 lbs. of nitrate of soda in August, 1921, and a like amount in March, 1922. No potash or phosphoric acid applied.

Experiment originally planned and laid out by R. S. Thurston.

Experiment harvested by O. C. Markwell, March, 1923.

Cane sampled in carload lots at mill by plantation.

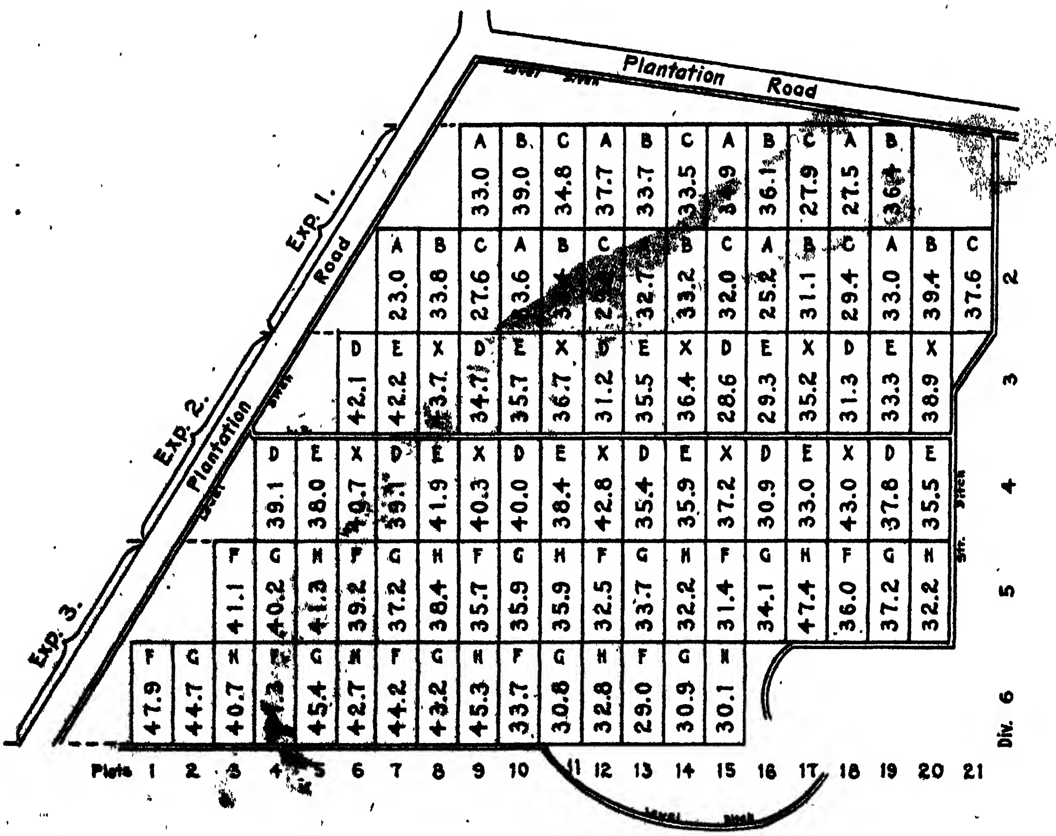
Lihue Experiment, No. 2.

In this test, all plots received a uniform application of nitrogen from nitrate of soda. In addition to this, ten plots received 500 pounds of reverted phosphate and 240 pounds per acre of molasses ash. Eleven plots got 240 pounds per acre of molasses ash in addition to the nitrogen. Eleven plots got nitrogen only.

Exp. 1. Reverted Phosphate, Residual Effect
Exp. 2. Plant Food Requirements.
Exp. 3. Forms of Nitrogen.

Lihue Plantation Co. Expts. 1, 2 & 3, 1923 Crop

Field 1.



The phosphoric acid and potash were applied in one dose to the young cane. The nitrogen was put on in two applications, one each season.

The results obtained from two crops are given below:

Treatment.	Total Pounds per Acre. N.	P_2O_5	K_2O	Tons Cane per Acre. 1921	1923	Average. Q. R.	Average Tons Sugar per Acre.
Nitrogen	150	0	0	45.2	35.4	8.49	4.75
Nitrogen and Molasses Ash	150	0	60	45.6	36.2	8.65	4.72
Nitrogen, Molasses Ash Reverted Phosphate.	150	70	60	46.5	39.4	8.61	4.92

Here, as in Experiment 1, the results are really within experimental error. There is no indication whatever of a response to potash. In the case of phosphoric acid, when the results are taken in conjunction with those of Experiment 1, there are indications of some slight response to phosphates, but this response is not enough to be profitable. But this does not mean that phosphoric acid fertilization should be discontinued as that would mean the further depletion of material from the soil and it would have to be replaced by larger doses in later years.

Details of Experiment

FERTILIZER—PLANT FOOD REQUIREMENTS

Object:
To determine the value of phosphate and potash in this soil.

Location:
Field 1.

Crop:
Yellow Caledonia, first ratoons. Previous crop harvested April, 1921. Not cut back.

Layout:
No. of plots, 32; size of plots, 1/10 acre, 108′ long x 40.3′ wide; comprising 24 straight lines, 40.3′ long x 4½′ wide.

Plan:

			August, 1921		March, 1922.
Plots.	No. of Plots.	N. S.	Sulf. of Potash.	Rev. Phos.	N. S.
D	11	484	0	0	484
E	11	484	150	0	484
X	10	484	150	500	484

Experiment originally planned and laid out by R. S. Thurston.
Experiment harvested by O. C. Markwell in March, 1923.
Cane sampled in carload lots at mill by plantation.

LIHUE EXPERIMENT NO. 3.

In this experiment we compared equal amounts of nitrogen from three different sources, namely, nitrate of soda, dried blood, and dried blood with a spring dressing of nitrate of soda.

The amounts of material used and the time of application were as follows:

1921 CROP.		1923 CROP.		Total Pounds of Nitrogen
August, 1919.	March, 1920.	August, 1921.	Feb., 1922.	per Acre.
645 lbs. N. S.	484 lbs. N. S.	645 lbs. N. S.	484 lbs. N. S.	175
833 lbs. Blood	484 lbs. N. S.	833 lbs.. Blood	484 lbs. N. S.	175
1458 lbs. Blood		1458 lbs. Blood		175

The results obtained from the two crops are as follows:

Treatment.	Tons of Cane per Acre. 1921 Crop.	1923 Crop.	Average Q. R.	Average Tons Sugar per Acre.
Nitrate of Soda	46.5	37.9	8.82	4.79
Blood and Nitrate of Soda....	45.6	38.0	8.82	4.74
Blood	43.9	37.5	8.49	4.79

These results show no preference as to which material we use as our source of nitrogen.

An interesting result of this experiment is the fact that in both crops the juices from the dried blood plots were better than the juices from the two other series of plots. We do not believe that this better juice was due to dried blood. We rather attribute it to the fact that in the dried blood plots all the fertilizer was applied the first season, and that no spring dressing was used. If the quality of the juices was affected by the blood, it should show in the second series of plots where both blood and nitrate of soda were used. But this was not the case. The average juices from the plots getting the spring dressing was the same, whether nitrate of soda or blood was used the first year. In other words, it would appear that it is the spring dressing that affected the juices, and not the blood.

This points to the great importance of careful study being made as to the value of the earliest possible fertilization as a means of improving the quality of our cane.

It is possible that it will be found advantageous to speed up our fertilizations so that all fields which are to be harvested fairly early in the year will receive all their fertilizer the first season and have the spring dressing omitted, thus giving the cane more time to mature. This would apply particularly to districts of heavy rainfall when maturity cannot be forced by the withholding of irrigation water.

Although the methods used are different, the ultimate results point to the same end. In one case we check growth by lack of water, in the other we attempt to check growth by lack of available nitrogen. But, in order not to lose much cane tonnage by the last method, it is necessary to feed the cane all the nitrogen it can possibly use in its early growth.

Details of Experiment

FERTILIZER—FORMS OF NITROGEN

Object:

To compare the value of the nitrogen in nitrate of soda only, in dried blood only, and in dried blood with spring dressing of nitrate of soda.

Location:

Field 1.

Crop:

Yellow Caledonia, first ratoons. Previous crop harvested April, 1921. This crop not to be cut back.

Layout:

	No. of	August, 1921.		March, 1922.	
Plot.	Plots.	Nit. Soda.	Blood.	Nit. Soda.	Total Nit.
F	11	645	0	484	175
G	11	0	1,485	0	175
H	11	0	833	484	175

Dried blood contained, approximately, 12% N.; Nitrate of Soda, 15.5%.
Experiment originally planned and laid out by R. S. Thurston.
Experiment harvested by O. C. Markwell in March, 1923.
Cane sampled in carload lots at mill by the plantation.

Liming Hawaiian Soils.

By W. T. McGeorge.

It is notable, on surveying the literature covering the liming of Hawaiian soils, that in spite of the fact that the laboratory studies strongly indicate a need of lime, comparative field experiments have rarely shown a profitable response. On the other hand, while opinions may vary, the practice of liming to a moderate extent is quite general. It may not be amiss, therefore, to compare results obtained here with some of the present day conceptions of lime requirement of soils and plants.

Field Observations

Hawaii. At Kaiwiki we note no response to lime (Yellow Caledonia cane) on applying coral sand up to four tons per acre, and burned lime at the rate of one ton per acre. Again we note no response at Hamakua Mill Co., (D 1135 cane) where ground rock and coral sand were applied up to seven tons per acre. In this case an effort was made to add enough lime to neutralize the acidity shown by analysis but samples taken later showed no reduction in acidity where two tons lime per acre were added. At Hilo Sugar Co. (Yellow Caledonia). on a soil showing five tons lime requirement by analysis, six tons burned lime and four tons sand both showed a slight response. Since these soils respond markedly to potash fertilization it is possible that response to liming in this experiment may have been due, at least in part, to a higher availability of potash on the limed plots. Greater availability of potash often results from additions of lime to the soil. At Paauhau (D 1135) 1 to 5½ tons hydrated lime gave no response; at Hawi (D 1135) ½ to 1½ tons burned lime gave no response, and at Niulii (Yellow Caledonia) a slight response was obtained with two tons lime per acre.

Oahu. At Waipio coral sand applied at the rate of ½ ton per acre, on a non-acid soil, gave a response with H 109 but none with D 1135. In similar experiments at Oahu Plantation a response was shown with Lahaina and H 109 but D 1135 again showed none. Both sand and gypsum were used in these experiments.

Kauai. At Kilauea certain tests have shown response to heavy applications of lime (Yellow Caledonia) while in others none is apparent even on acid soils. At Grove Farm no response was obtained, on virgin soil, (Yellow Caledonia) on applying as high as ten tons coral sand per acre.

Laboratory Studies

The early bulletins of the Station call attention to the readiness with which lime is leached from our soils. Makai soils are much higher in lime than mauka and cropped soils much lower than uncropped ones. In view of the relation of soil acidity to the biological activities we note special attention to have been given to this phase of liming. The replacement of other elements by lime has also been studied.

Biological activities are found to be very low in the acid soils, the addition of lime as oxide, carbonate or sulphate increasing nitrification of the soil nitrogen or that added as ammonium sulphate or blood. In the soils higher in lime less stimulation is noted. In another experiment we note burned lime and gypsum decreasing nitrification, from which variation in soil types is apparent. It is significant that in one set of experiments an increase in nitrification with increase in lime up to neutrality was found, indicating the advisability of liming to neutrality in such cases.

Coral sand has been shown to increase the nitrate content of the drainage water while burned lime and gypsum decreased it. A slight increase in the potash content was also noted while all forms of lime reduced the loss of phosphoric acid.

As regards the effect of lime on the mechanical properties we note a retarding of the movement of water, a flocculation of the clay into larger aggregates, and an increase in cohesion, apparent specific gravity, and vapor pressure.

Lime as Plant Food

Hilgard has said, "limestone country is a rich country," and Hall of the Rothamsted Experimental Station is quoted as having stated that any soil containing less than 1 per cent calcium carbonte will be benefited by liming.

Let us first consider the cane plant itself. It has long been known that certain species of plants are affected and others more or less indifferent to the soil reaction. There has resulted therefrom a botanical classification of calciphile (lime-loving), calcifuge (lime-avoiding), and indifferent; or acid tolerant, acid intolerant and indifferent. We find sugar cane thriving on a wide variety of island types. Observations, therefore, indicate that the cane is more or less indifferent to soil reaction within certain limits. It is evident, therefore, that the principal direct relation of lime to the growth of cane is as a source of plant food, or at least other than as a corrector of soil acidity. The availability of calcium being lowered by soil acidity, are our soils in need of lime applications as plant food? As previously noted, lime is readily leached from our soils and is probably the dominant constituent of the drainage water, being in solution principally as the bicarbonate. With few exceptions lime as carbonate is not present in the soil. It is evident from a survey of investigations on local soils that it is present primarily as the silicate. Thus we have the acid soils as the dominant type in the islands. While a supply of calcium as a plant food for the cane is essential, it may be safely stated that the drain that the cane plant makes upon the supply of this element is, by far, less than that removed in the drainage. In other words, light applications of lime would supply the plant food needs of the cane even in those soils of low lime content and it would appear to be good policy to regularly make light applications to the soils low in lime, regardless of any indication of visible response to such practice. In experiments in which different forms of lime have been compared, those in which a response was obtained showed such with the sulphate as well as the oxide or carbonate. The former functions primarily as a plant food while the latter as neutralizers of acidity. Does this offer a clue to the fact that response to liming is rarely observed? In the absence of calcium in other forms, calcium as silicate is known to function as a source of plant food. There is present in the irrigation water and rainfall

comparatively large amounts of carbon dioxide, which source is probably augmented by that produced in the respiration of the cane roots. There results therefrom the solution of lime through a hydrolysis of the silicate in the presence of carbonated water. It is evident, then, that calcium silicate being present in appreciable amounts in our soils, supplies, except in isolated cases, the lime needed as plant food by the cane. On this basis we would not expect a response in cases where the lime functions primarily as a source of plant food, unless an actual deficiency exists.

Soil Acidity

The chief reason for applying lime to a soil is to correct acidity, the function of lime is therefore primarily that of an indirect factor in plant growth. It is a notable fact that most plants produce best growth in the absence of acidity. In acid soils we have an environment productive of low availability of the important plant food constituents of the soil, retarded decomposition of organic matter, prevalence of certain plant diseases, etc. In estimating the lime needs of our soils the Veitch method has been widely used. It is recognized that this method only measures the amount of lime which the soil will absorb under the conditions of the analysis and therefore does not answer satisfactorily the amount of lime to apply. Some of our soils containing as high as 2 per cent lime of high availability show a need of lime by the Veitch method. It is possible that in such, a part of the lime is fixed as silicate. It seems imperative, then, that a knowledge of the nature of the acidity must be considered in estimating the lime requirement. Is it due to basic exchange? Does the mineral or organic acid theory apply? Is the phenomenon of selective absorption involved? Is there present a reducing or oxidizing environment? Is the acidity due to a hydrolysis of the salts of aluminum, iron or manganese, the solubility of which is increased by acid conditions and absence of lime? The suggestion has been made by several investigators that the effect of aluminum and manganese in acid soils seems likely to prove of more importance than the neutralization of active acidity. Lime is the principal agent for rendering these salts inactive.

In the heavy island soils we note a reducing environment, high colloidal properties and absorptive power, high basicity or low silicate content, and excessive amounts of iron, aluminum and manganese as being the principal possible factors involved in the acidity of our soils. As for any actual mineral acidity the heavy nitrate applications probably furnish sufficient base to prevent such accumulation. Absence of necessary work on soil acidity, covering this phase of the problem, prevents any conclusions being drawn regarding the extent to which the above factors apply.

Biological Activities

We have in the soil a culture medium for micro-organisms which has a direct bearing on soil fertility. It is apparent, therefore, that the reaction of such a medium is of vital importance in the proper functioning of the biological processes. It has been proven beyond question that in most of our soils a stimulation of bacterial activities related to the decomposition of plant residues and especially those concerned in the nitrogen cycle results from lime applications. Investigations have indicated the optimum conditions for nitrification to

be liming to neutrality. In the heavy applications of sodium nitrate, as practiced in the Islands, we supply to the cane the plant food which lime, as our experiments show, functions in making available. It is therefore evident that we could hardly expect a response from addition of lime where nitrate is also applied if a low nitrifying power is the limiting factor.

The action of lime and nitrate of soda are therefore interrelated. In sodium, of sodium nitrate, we have a base which functions to a limited extent as a neutralizer of soil acidity. That is, sodium nitrate applications tend to lower the acidity of the soil. At the same time we are adding nitrogen in a form which liming would supply to the plant through a stimulation of the nitrification of soil nitrogen.

Mechanical Effects of Lime

There is a tendency in many of the heavy clay island types to puddle or become compact. On a normal clay soil lime tends to flocculate the clay particles and produce what is known as a crumby structure. Experiments have shown that lime acts very favorably in improving the physical properties of Hawaiian soils, thus producing a healthier medium for plant growth.

Chemical Effects of Lime

Chemically, lime possesses several important properties closely connected with the changes going on in the soil solution. In solution as calcium bicarbonate it is the principal agent involved in the basic exchanges taking place in the soil solution. While there have been opposing opinions offered as to its relation to the availability of potash, results obtained in the study of local soils show applications of lime as oxide, carbonate and sulphate, principally the latter, to increase the soluble potash in the drainage. It appears to be also favorable to the formation of more readily available forms of phosphoric acid.

Other favorable reactions include neutralization of organic toxins and the elimination of the soluble toxic inorganic salts such as aluminum. The relation of the latter has not been studied with reference to local soils, but it is probable that they may be a factor in our fertility problems.

Conclusions

A superficial observation, then, of the effect of liming the cane lands of the Islands indicates that under the present practices a deficiency of lime for plant food is the principal limiting factor in anticipating response or no response to lime applications. In spite of the fact that laboratory studies show more favorable mechanical condition, lower acidity and a stimulation of the nitrification will result from liming, only in isolated cases has the cane shown any response to this practice. This is probably due to the indifference of sugar cane to the soil reaction, within a certain range, and the heavy nitrate applications which correct the low nitrification.

While considerable work has been done on the effect of lime on the biological processes in Hawaiian soils and the effect on the physical properties, the need for further knowledge of the chemical effects and the nature of the existing acidity is apparent in attempting to explain some of the results obtained in field trials.

The Acidity of Hawaiian Soils.

By W. T. McGeorge

Hawaiian soils, while characteristically basic, are, with rare exceptions, acid in reaction and usually show a high lime requirement by the Veitch method On the other hand, experiments and general observations have rarely shown any indication that sugar cane is materially aided by liming these soils. As a whole, the results indicate an indifference to soil reaction on the part of the sugar cane plant, or an acidity, the nature of which is not toxic toward the cane roots. In view of this the question arises: Is the nature of the acidity a factor?

Comparatively little work has been published showing the relation of the lime requirement of soils as determined by the various methods and the hydrogen ion concentration in soils high in iron, aluminum, and manganese oxides and in which these oxides are often in excess of silica. Such a comparison has recently been made in this laboratory in order to obtain information relative to the nature of acidity in such types. In this case it is not a question of the merits of the different methods.

Fourteen soils were selected varying in pH* from 4.63 to 8.01. The composition of these soils as to the most important basic constituents and silica is given in the following table. The results are expressed on the air-dry basis in order to illustrate the variation in the moisture content of the soils in the air-dry state.

TABLE 1.

Partial Analyses of Soils.**

Soil No.	H_2O	TiO_2	Fe_2O_3	Al_2O_3	Mn_3O_4	CaO	SiO_2	Organic *** and Vol.
848	12.47	6.0	11.17	19.33	.18	1.23	40.9	10.63
849	14.20	7.2	10.37	18.88	.13	1.42	39.8	9.11
367	9.60	12.2	22.54	28.51	.20	.61	9.8	15.80
765	12.03	8.0	22.54	15.46	.25	1.15	15.1	11.57
186	19.60	6.0	13.56	15.09	.26	1.23	13.2	29.63
187	22.20	4.4	13.56	18.04	.25	1.01	17.5	29.63
621	4.11	7.4	21.74	27.36	.30	.98	31.7	10.69
409	9.10	10.0	15.56	25.64	.22	.84	33.8	9.09
734	8.90	5.8	14.16	28.79	1.10	.92	33.9	11.25
722	6.04	9.8	15.76	28.24	.43	.86	31.0	13.34
408	7.70	9.4	14.56	26.04	.77	.98	33.7	11.50
872	9.17	5.6	13.96	15.44	.34	3.14	42.3	10.58
3	7.00	5.0	23.74	15.51	.40	3.25	30.8	10.24

** Analyses by fusion with sodium carbonate.

*** Does not include moisture given in column two of this table.

* In expressing acidity in terms of pH a value of 7.0 indicates neutrality, above this point, alkalinity, and below, acidity.

848 is a heavy, black, clay, adobe soil, high in water soluble iron and aluminum, irrigated land, low elevation, Waimanalo plantation.

849 is the subsoil to 848 and similar in texture and color.

367 is a yellow clay loam as is also 399. Both are from Kauai upland soils, unirrigated land.

186 is a sandy loam high in organic matter and combined water from Honokaa plantation.

187 is the subsoil to 186, similar in texture but lighter in color.

621 and 408 are red clay loams from districts where rainfall is low. The former is from Pioneer Mill, medium elevation, and the latter from Ewa plantation, low elevation.

734 is a chocolate brown silty loam from a manganiferous area, Oahu plantation, upland soil, irrigated land.

722 is a brown clay loam from Waipio substation.

409 is a red clay loam, subsoil to 408.

872 is the same type as 848 but taken from a section near the sea and high in coral.

3 is a sandy clay loam from the Experiment Station plots, Makiki, derived from and underlain with black volcanic ash.

765 is a yellow silty loam from the Hilo district, rainfall heavy, land unirrigated, clay highly hydrated and high in organic matter.

These soils have been selected from sugar lands located on the four major islands, Oahu, Maui, Kauai and Hawaii, and represent lowlands, uplands, humid, and more or less arid districts.

The lime requirement or acidity of a soil is attributed to such phenomena as the actual presence of mineral or organic acids, absorptive or adsorptive properties of colloidal material, free hydrogen ions or the presence of certain specific compounds which, through hydrolysis or replacement, increase the hydrogen ion concentration of the soil solution.

Extensive and comprehensive reviews of the various methods of determining soil acidity are available (1), which makes such a review unnecessary here. Those used in this investigation include the treatment of the soil with the salts of strong acids and strong bases, for example, the Hopkins method (2) which calls for the use of potassium nitrate or chloride; weak acids and strong bases, for example the Jones method (3) using a solution of calcium acetate, the Loew (4) method using potassium acetate, the Carr (5) method using potassium sulphocyanate; weak acids and weak bases, the Truog (6) method using zinc sulphide. Other methods included the Veitch (7) and the Hutchinson and MacLennan (8) methods which utilize solutions of calcium hydrate and bicarbonate respectively; Lyon and Bizzell (9), in which barium hydrate is used in a somewhat similar manner; the Conner (10) method and that of Rice and Osugi (11), in which the hydrolysis of esters and sucrose respectively are used; Hollemann (12), which measures the per cent lime soluble in water saturated with carbon dioxide; Immendorf (13), in which a back titration of N/5 sulphuric acid, and in which the soil has been boiled, is used.

A number of qualitative tests were also applied to these soils and include the litmus paper test; those of Veitch and Truog, which have already been

described; the Comber (14) method, which uses an alcoholic solution of KSCN, the Loew (4) method, which uses a solution of KI in starch paste, and as modified by Daikuhara (4), using starch iodide paper instead of the starch paste as a test for free iodine.

QUALITATIVE METHODS

The results obtained by the qualitative methods are given in the following table:

TABLE 2.

Qualitative Tests For Acidity

Soil No	Litmus.	Veitch.	Loew.	Loew-Daik.	Truog.	Comber.	pH.
848	acid	colorless	blue	colorless	positive	dark red	4.63
849	"	"	"	"	"	" "	4.80
367	"	"	colorless	"	"	faint red	4.88
399	"	"	"	"	negative	" "	4.97
765	"	"	"	"	"	" "	5.56
186	?	"	"	"	"	" "	5.73
187	"	"	"	"	"	" "	5.98
621	"	"	blue	"	"	" "	5.98
409	"	"	colorless	"	"	" "	6.32
734	"	"	"	"	"	colorless	6.66
722	neutral	"	"	"	"	"	7.00
408	"	"	"	"	"	"	7.08
872	alkaline	red	"	"	"	"	7.67
3	"	"	"	"	"	"	8.01

Of the above qualitative methods the litmus, Veitch and Comber appear to be best suited to local soil types as an indication of absence of adequate lime supply. The Loew and Truog methods appear to be of little value, assuming the pH values as standard for comparison. The reaction involved in the latter two methods requires the presence of an acid, which in the Loew and Loew-Daikuhara methods sets free iodine from KI, being indicated by the starch paste or starch iodide paper and which in the Truog method liberates H_2S from ZnS as indicated by the lead acetate test paper. These methods apply only in those soils of pH 4.8 or less and indicate that these reactions are inhibited in our soil types or that in those soils of low H ion concentration the small amounts of iodine or H_2S are absorbed and not set free on boiling. The Comber method showed some promise of yielding information relative to the nature of the acidity, and in view of its relation to the more advanced conceptions of soil acidity, in which the salts of iron, aluminum and manganese play a prominent part, more time was devoted to a study of this method. The reagent used in this test, KSCN in alcoholic solution, will, in the presence of soluble iron, increase the concentration of $Fe(SCN)_3$ in the liquid phase to such an extent as to greatly increase the delicacy of the reaction. From the composition of Hawaiian soils, one would ordinarily attribute acidity to be in large part due to these elements.

According to Comber, the red color increases in depth on standing. As thus applied to Hawaiian soils, manganese dioxide, which is present in practically all types, introduces a factor, which, within a certain pH range, materially enhances the value of this method, or, viewed from a different light, may add to its value. In the following table are noted observations made with this test immediately after the soil had settled and at 24- and 48-hour periods:

TABLE 3.

Showing the Factor of Time in the Comber Method

Soil No. No.	pH.	15 Min.	24 Hr.	48 Hr.
848	4.63	dark red	dark red	dark red
849	4.80	"	"	"
367	4.88	light red	light red	light red
399	4.97	red	red	red
765	5.56	"	"	"
186	5.73	light red	light red	light red
187	5.98	"	"	"
621	5.98	"	blue	blue
409	6.32	"	"	"
734	6.66	colorless	"	"
722	7.00	"	"	"
408	7.08	"	"	"
872	7.67	"	colorless	"
3	8.01	"	"	colorless

This blue color was found to be due to manganese dioxide and it is apparent from Table 3 that we may expect soils of pH less than 5.5 to show a permanent test for soluble iron, while within the range of 5.5 to 7.0 MnO_2 will change the red color to a greenish blue. This change in color is due directly to MnO_2 and not to soluble manganese salts. For example, on adding MnO_2 to 848 there resulted a gradual fading to greenish blue, while on adding manganese salts there was no change in color, the red color of undissociated $Fe(SCN)_3$ being permanent.

It was further suggested by Comber that if $FeCl_3$ be added to this reagent, thus developing the red color before shaking with the soil, the iron present in the liquid phase will be displaced by the lime in all alkaline soils. As thus applied to the soils under investigation, further peculiarities were met. The observations noted were as follows: In soils 848 to 187 there was no greater amount of color than where no $FeCl_3$ was used. Soils 621 to 408 all showed no greater amount of color and turned blue in 24 hours. Soils 872 and 3 remained colorless. The results clearly show the high absorptive capacity of the soil colloids and the influence of pH range on the color of $Fe(SCN)_3$. The delicacy of the reaction in these soils is greatly increased by using an ether-alcohol solvent for the reagent.

QUANTITATIVE METHODS

A comparison of the quantitative methods of determining acidity or lime requirement with pH values is given in Table 4. In Part 1 is tabulated the methods

expressing lime requirement in terms of pounds calcium oxide per acre and in Part 2 methods of determining soil acidity which are expressed in other terms.

TABLE 4, PART 1.

Comparing pH with Lime Requirement in Pounds CaO per Acre

Soil. No.	pH.	Veitch.	Hutch. MacLen.	Lyon Bizzell.	Hopkins.	Loew.	Jones.	Carr.
848	4.63	11460	11080	11480	3570	9360	6840	7020
849	4.80	11460	13440	12820	6880	11580	8570	9000
367	4.88	6390	9070	8060	170	3630	4860	1200
399	4.97	6750	6720	7990	100	3510	3600	....
765	5.56	15120	11500	12300	100	4410	6480	4290
186	5.73	22500	9820	13230	170	6480	6680	2200
187	5.98	24510	9570	11380	170	2490	5580	1000
621	5.98	2340	1510	250	85	1480	1260	....
409	6.32	1350	2680	200	60	810	900	....
734	6.66	1350	3520	120	40	1080	1260	....
722	7.00	660	126	60	40	420	360	....
408	7.08	1680	126	310	40	330	360	....
872	7.67	660	—2680	alk.	alk.	270	alk.	....
3	8.01	660	—6630	alk.	alk.	210	alk.	....

TABLE 4, PART 2.

Soil No.	Rice Osugi*	Conner **	Immendorf***	Hollemann****
848	.0750	9.6	13.25	.008
849	.1160	4.4	13.40	.007
367	.0190	13.0	8.50	.009
399	.0130	10.0	7.75	.013
765	.0536	24.0	15.90	.015
186	.0254	10.0	20.25	.017
187	.0520	6.0	20.10	.016
621	.0150	8.0	10.0	.023
409	.0025	2.8	11.75	.020
734	.0050	10.0	14.90	.023
722	.0153	2.0	15.10	.033
408	.0136	2.8	13.00	.027
872	.0395	4.4	21.10	.081
3	.0230	2.0	24.10	.131

* Gms. CuO per 2.5 gms. soil.
** cc. N/20 alkali per 10 gms. soil.
*** cc. N/5 acid neutralized by 10 gms. soil.
**** per cent CaO soluble in CO_2 saturated water (1:5).

Let us first consider the results obtained with the Veitch, Hutchinson-MacLennan and Lyon-Bizzell methods, which in a manner involve similar principles. In the two former, amelioration of soil acidity is effected by methods closely resembling field practice, a solution of $Ca(OH)_2$ in the one case and of $CaHCO_3$ in the other. It is evident, however, that in addition to a neutralization of actual acidity, and a replacement of soluble iron, aluminum and manganese

in their soluble salts, the acidity will appear greater than it really is, due to physical absorption by the soil colloids, not denying, however, that lime may be of benefit to the soil in other ways than neutralization of soil acidity.

In the results obtained by these three methods there is a general agreement in the soils of pH 4.6 to 5.5. Soil 186 and subsoil 187 show a wide variation. From this, it is evident that in this type acidity is due to several acid constituents as shown by the different degrees of reactivity with the different basic combinations. Absorption is also a factor in this soil, at least one might interpret such from the high content of water of hydration and the resulting colloidal properties usually associated with such types. Comparing 187 and 621 it will be noted that both show a pH of 5.98, while there is a difference of 10 tons lime requirement by the Veitch method, 4 tons by the Hutchinson-MacLennan method, and 5.5 tons by the Lyon-Bizzell. These results indicate a high potential acidity in the former, probably due to the presence of acid reacting organic compounds, and an acidity in the latter of greater intensity, this soil being very low in organic content. The soils of lower H ion concentration given in the table all show a greater degree of variation. In general, it may be said that these methods, in the main, neutralize all types of acidity and will usually agree, close enough for practical purposes, on all our highly acid types where the ratio of lime absorbed by the colloids to that used in neutralizing acidity is low. But in those soils of pH 6 to 7, and these are the less important, in which there is a higher ratio of absorbed lime to that neutralized by soil acids, there is greater variation and less agreement, the Veitch method showing absorption even in the alkaline soils. Specific information relative to the nature of acidity is wanting, except that the Veitch method gives higher results, as compared to actual H ion concentration, on soils the acidity of which is due to organic matter, than where due to other factors. In other words, the Veitch method has the advantage in the case of soils of high potential organic acidity if it is desired to estimate the lime needed to neutralize the soil, as in such types this factor is not indicated by the H ion concentration.

In the Hopkins, Jones and Loew methods we have the much discussed acidity by basic replacement or absorption. It is generally conceded that these methods indicate mineral acidity as shown by the solution of aluminum, iron and manganese in the extracts of acid soils treated with solutions of the salts which are the basis of the above methods, and the knowledge that the salts of these elements react acid through hydrolysis. Practically all soils show a higher acidity where acetates are used than where chlorides or nitrates and this is strikingly apparent in Hawaiian soils. Even in our most acid types it will be noted that the lime requirement, as indicated by the Hopkins method, is practically negligible. Both KCl and KNO_3 were used and the results by both salts checked very closely. It is significant that the highest results were obtained on the soils of highest H ion concentration and in which soluble iron and aluminum salts were present in large amounts and that in these soils potassium acetate gave higher results than the calcium acetate.

The Conner and Rice-Osugi methods show quite ~~a~~ wide variation in the hydrolytic action of these soils as measured by the hydrolysis of sucrose and ethyl acetate. These compounds are hydrolysed or decomposed in the alkaline

soils as well as the acid and there appears to be little relation between the H ion concentration and hydrolysis, indicating that this reaction is due in part to other factors than acidity.

The Immendorf method, which acts as a measure of soluble bases is of little or no value in these highly basic soils either as a measure of lime requirement or as indicating the nature of acidity. All acid extracts of these soils were high in iron and aluminum except number 3.

On the other hand the Hollemann method which measures the solubility of lime in water saturated with CO_2 shows a very close relation to pH values. There is a gradual increase in the solubility of lime in this reagent, with decrease in H ion concentration. These results clearly indicate that the solubility of lime is definitely associated with the H ion concentration of these highly basic soils, both as a neutralizer of actual soil acidity and in the replacement of iron, aluminum, and manganese in the soil solution due to their relative positions in the electromotive series. The results obtained show beyond a doubt that acidity in Hawaiian soils is largely a question of presence or absence of readily available calcium compounds.

Carr (5) has developed a quantitative method from that of Comber, using the red color of $Fe(SCN)_3$ as an indicator, after determining the pH at which this salt becomes colorless in solution. As thus applied to Hawaiian soils some interesting results were obtained. In highly acid soils which give a positive test for iron the titration is to a green or bluish green rather than a colorless solution. A pH of 5.4 is the turning point and the change is rather indefinite. However in titrating from colorless or green to red the color change is even yet more indefinite and in the highly manganiferous soils considerable acid may be added without changing the pH. For example, an acid reacting soil containing 7 per cent MnO_2, having a pH of 5.9, on titrating with alcoholic N/10 sulphuric acid still showed a pH of 5.6 after adding 120 cc. and the red color of $Fe(SCN)_3$ had not yet appeared. The observations noted above are of considerable value in interpreting the role of manganese in the acidity of our manganiferous types.

DISCUSSION

In attempting an interpretation of these data the results show that the acid soils of the humid districts will contain considerable acid reacting organic matter of high potential acidity not indicated by the H ion concentration. Such types will usually show a very high lime requirement, but not necessarily a low pH. Other factors such as absorption or adsorption, presence of silicic acid, complex acid-reacting silicates and hydrolysible salts of aluminum, iron and manganese appear also to be a factor.

In ascertaining the role of these elements their presence is usually sought in the salt solution extracts. Table 5 gives the per cent iron and aluminum oxides present in the potassium nitrate, or Hopkins method extract, and the potassium acetate or Loew method extract of these soils.

TABLE 5.

Showing per cent Fe_2O_3, Al_2O_3 in the Salt Extracts of Acid Soils

Soil. No.	pH.	KNO_3	$KC_2H_3O_2$
848	4.63	.228	.183
849	4.80	.220	.192
367	4.88	.043	.017
399	4.97	.044	.024
765	5.56	.082	.027
186	5.73	.085	.056
187	5.98	.073	.022
621	5.98	.100	.086
409	6.32	.189	.180
734	6.66	.072	.097
722	7.00	.113	.158
408	7.08	.194	.196
872	7.67	.268	.252
3	*8.01*	*.126*	*.174*

It has usually been noted that (10) the aluminum content of the acetate extract is lower than that of the nitrate. This is explained theoretically by the difference in the hydrolytic products of the reactions involved, namely aluminum acetate, of which the products of hydrolysis are aluminum hydrate, and free acetic acid and aluminum nitrate which is retained in solution as the acid salt. In the acid soils of pH 4.6 to 6.3 the iron and aluminum content is less than in the nitrate extract, while in the soils of pH 6.6 to 8.0 this relation does not hold. Judging from the color of the ammonium precipitate and qualitative tests, iron was present principally in the extracts of the more acid soils while scarcely more than a trace was to be found in the extracts of the soils of pH 6.0 to 8.0 It should be noted that the extracts of the alkaline soils contained just as much or possibly more iron and aluminum than those from the acid soils. The formation of acid salts is, however, inhibited by association with higher soluble lime content.

This influence of easily soluble bases is apparently a very important factor. The solubility of silica and silicates is of some importance. The ratio of iron, aluminum and calcium to silica was determined by using N/5 nitric acid as a solvent and the results are given in Table 6.

TABLE 6.

Showing Ratio of Easily Soluble Bases and Silica as Measured by Solubility in N/5 Nitric Acid.

Soil No.	$\%SiO_2$	$\%Fe_2O_3$	$\%Al_2O_3$	$\%CaO$	pH.
848	.120	.032	.468	.435	4.63
849	.137	.026	.552	.396	4.80
367	.012	.005	.318	.051	4.88
399	.012	.100	.182	.108	4.97
765	.097	.022	1.518	.145	5.56
186	.252	.043	3.920	.423	5.73
187	.386	.032	3.830	.141	5.98

Soil No.	$\%SiO_2$	$\%Fe_2O_3$	$\%Al_2O_3$	$\%CaO$	pH.
621	.067	.008	.175	.176	5.98
409	.105	.007	.138	.202	6.32
734	.270	.004	.537	.278	6.66
722	.116	.006	.233	.253	7.00
408	.141	.009	.174	.269	7.08
872	.287	.031	.602	1.045	7.67
3	.493	.011	1.585	1.185	8.01

It will be noted that in all types easily soluble, aluminum is far in excess of iron and highest in the highly organic soils. In general, all four constituents show wide variations in the different soil types and there appears to be no relation between their ratio and acidity. Apparently, the mineral acidity or H ion concentration is not primarily entirely a function of the solubility of these elements, but rather a function of other factors which limit the formation of acid or basic combinations.

Eliminating such abnormal types as 848 and 187 and considering only those in the series which are more typical of the average island soils, there is a tendency toward decreasing solubility of aluminum compounds, less so the iron, and an increase in soluble calcium compounds with decrease in H ion concentration. This ratio probably has an important bearing on the mineral acidity or acid-reacting compounds of these elements.

EVIDENCE OF MINERAL ACIDITY OR PRESENCE OF ACID REACTING INORGANIC COMPOUNDS.

As previously noted in the ammonia precipitates obtained on the nitrate and acetate extracts, only traces of iron were present even in soils 848 and 849, both of which gave strong tests for iron salts by the Comber method. This type of acidity is greatest in the heavy clay soils in which drainage is poor and aeration low and of which the above two samples are typical. Iron, then, is not an important factor in the acidity of average island soils and its activity is confined to the most acid types, and even in these evidently plays a secondary role to aluminum.

Manganese, on the other hand, is a factor only in those soils of low acidity. Of the manganiferous samples examined, the pH values were all 5.9 or higher. It was noted also, in an examination of the subsoils from these types, that in all cases the subsoil was of a lower H ion concentration than the top soil. Expressed in pH values the difference was .6 to .9 pH less acid. Judging from the relative positions of calcium and manganese in the electromotive series one would theoretically anticipate such to be true. The calcium apparently replaces manganese in the soil solution, the latter usually occurring in these soils deposited on the soil grains as a coating, while the characteristically open texture of the manganiferous soil favors the leaching of lime into the subsoil.

Aluminum is present in easily soluble form in all island types, highest in the humid districts and lowest in the arid. Apparently one of the principal roles which lime plays in Hawaiian soils is in its relation to the acidity of aluminum salts which appear to be present in available form even in the alkaline types.

This is best shown by the progressive increase in per cent lime soluble in water saturated with CO_2 with increase in pH, and the further fact that aluminum appears to be present in equally available form in the acid and alkaline soils, since aluminum may be present either as an acid or basic salt, depending upon environment. It is significant that soil 186 represents a comparatively unproductive area, much more so than 848, for example, although the latter is a much heavier soil and very poorly aerated. It has been found that phosphate is much more available in the lowland sections of the Islands than in the uplands. The principal inherent differences in the soils from such districts are higher acidity and lower lime content of the latter, and a greater rainfall. An investigation of these phenomena indicates that in the absence of lime in the more acid upland soils phosphoric acid has combined with aluminum, which compounds have become hydrated and hence less available as there is no consistent difference in the total phosphate content of upland and lowland soils, the principal variation being in the availability. It is believed that these facts lend some indication of the presence of acid mineral salts and that they are a factor in the acid reaction of island types.

The importance of silica as a factor in this acidity appears to be, at least, closely related to that of aluminum. Silicates are present in Hawaiian soils in a comparatively soluble form, as is shown by its presence in the island streams and its solubility in the dilute and strong acid extracts of the soil. It will be noted in Table 4 that the lime requirement as determined by potassium acetate is greatly in excess of that shown by extraction with a solution of potassium nitrate. In the case of aluminum silicate the acidity from potassium acetate is due entirely to acetic acid formed from the hydrolysis of aluminum acetate. There results a greater acidity than where acid salts are formed and relatively less aluminum in solution.

Also when anhydrides become hydrous there is a greater tendency to assume acid or basic properties. This would apply to oxides of iron and aluminum as well as silicates and it is evident therefrom that these compounds are more or less amphoteric depending upon environment. In our humid districts, or those in which rainfall is heaviest, there has been noted a rapid leaching of lime. Where present as a double silicate of calcium and aluminum there may result a complex aluminum silicate containing no lime and of more acid tendencies. Soluble forms of lime have been found to be very low in the soils from these districts. The acid or alkaline state of aluminum silicates will depend upon the amount of water of hydration and ratio of silica to alumina. Conner (10) found that ignition destroys the acid-reacting properties of clays as determined by the Hopkins method. Loss of water of constitution therefore lowers the acidity of aluminum silicates. He found that those silicates of low water of combination were not acid and that those containing considerable water and silica were highly acid. Applying these theories to island soils we find the soils from the districts of low rainfall to be low in acidity, while the reverse is true of the soils from the humid districts. Examples of the former are soils 621, 408, 409, 734, 722, while soils 765, 186, 187 will illustrate the latter. The higher organic content of the latter must, however, not be overlooked. The largest humid district under cane cultivation is the Hamakua coast section on the Island of Hawaii.

Available lime and potash are low in this section and water of constitution or hydration is high. The moisture content of the air-dry soil is often as high as 25 per cent and the maximum water holding capacity over 100 per cent. Such conditions actively favor the formation of acid aluminum silicates. There is a progressive decrease in rainfall from the Hilo section of this coast to the Kohala district at the northernmost extremity of the island. Accompanying this decrease in rainfall there is a decrease in maximum water-holding capacity, water of hydration and acidity of the soil, all of which lends proof that the acidity of our humid districts is due in a large measure to alumino-silicic acids or acid silicates. In the drier sections where the cane is grown under irrigation, rainfall being too low to support maximum growth, we find more lime present in soluble forms and that in these more or less arid districts there is decidedly less response to potash fertilization. It may be of interest to state that the water of hydration is lower in the soils from these districts, the moisture content of the air-dry soil usually being within the range of 5-10 per cent. We have under these conditions more active double silicates of potash, lime, soda, and magnesia which partially prevent the formation of the alumino-silicic acids through neutralization.

SUMMARY

In this paper are reported the results obtained on application of the Hopkins, Jones, Loew, Carr, Truog, Veitch, Hutchinson-MacLennan, Lyon-Bizzell, Conner, Rice-Osugi, Hollemann, Immendorf and hydrogen electrode methods of determining soil acidity as applied to highly basic laterite soils.

While some comments have been offered regarding the merits of these methods on such soil types the main purpose has been to interpret therefrom the nature of soil acidity in our island soils.

In the humid districts acid-reacting organic matter is an important factor, while in those sections of low rainfall this is true to a much less extent.

Mineral acidity is due in most part to aluminum salts and alumino-silicates, the later predominating in the humid districts. Iron is a factor only in the very acid soils of pH 4 to 6 while manganese is a factor only in the less acid types of pH 5.5 to 7. Water of combination or hydration is also an important factor in all types.

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Notes on Seedling Work—1923 Oahu Propagation.

By Y. Kutsunai

In October, 1922, several trips were made to learn the tasseling conditions in respect to seedling work. About 4,400 tassels were collected between November 22, 1922, and January 22, 1923, a period of two months. About a quarter of a million seedlings germinated. About 100,000 were transplanted, and of these 40,000 were sent to Manoa substation, 25,000 to Waipio substation, 15,000 retained at Makiki, and 3,000 sent to Vineyard Street nursery. A few flats, each containing three to four thousand seedlings, were given to Ewa Plantation Company and Kamehameha School. At the end of April, 1923, Waipio and Makiki had finished planting seedlings, while the Manoa substation had put out about 10,000 of them.

Details of this year's seedling work are here recorded:

Plan

This year, cane seedlings for unirrigated mauka fields were to be the major object and as many as possible were to be grown. Seedlings for warm, irrigated fields, and other special seedlings were to be grown on a small scale. Accordingly, the following plan was adopted:

(1) As many tassels as possible to be collected from the following:
   Red Tip,
   Striped Tip,
   Yellow Tip,
   Other mauka canes.

(2) Tassels wanted in small quantities:
   H 109,
   Striped Mexican,
   Lahaina,
   D 1135,
   H 5978.

(3) Special tassels wanted for special reasons:
   Uba,
   Badila,
   H 109 seedlings, 1918 O. P.,
   Native canes.

General Survey of Available Tassels

In October, 1922, extensive trips were made throughout the island of Oahu to locate fields in which the above tassels were likely to be available. Permission to secure tassels from these fields was also sought. Conditions found were:

Tassels of	Availability.
Striped Tip	Very few
Yellow Tip	None
Red Tip	None
H 1801	Many
H 3001	Very few
H 109	Many
Striped Mexican	Very few
Lahaina	Many
D 1135	Many
H 5978	Many
Uba	Very few
Badila	Many
H 109 Seedlings, 1918 O. P.	Very few
Native canes	Very few

In view of the shortage of Tip tassels, Mr. W. C. Jennings, of Kohala, was requested to supply Makiki with Tip tassels in exchange for some of the tassels abundant on Oahu.

Choosing Field For Cutting Tassels

Spots were chosen where two desirable varieties grew near each other, preferably the pollinating variety to the windward side, developing tassels a little earlier than the variety to the leeward side where the tassels were to be cut. The following fields were chosen from this standpoint:

Mother Variety.	Field.
H 1801	Makiki field 11
H 109	Honolulu Plantation Co. field 26
H 109	Ewa Plantation Co. field 25A
H 109	Makiki field 2
H 109	" " 3
Striped Mexican	Waipio substation field 37
Lahaina	Honolulu Plantation Co. field 26
D 1135	" " " " 12
H 5978	Makiki field 11
Uba	Federal Exp. Station field
Uba	Makiki field 12
Badila	Ewa Plantation Co. field 25A
H 109 Seedlings	Makiki field 18
Native canes	" " 12
Striped Tip	Manoa field 6

That there should be two or more varieties flowering close together and at the same time for proper development of seeds (caryopsis) of sugar cane was clearly brought out by H 109 seedlings grown at Makiki in 1918, and 1923. On

December 28, 1917, in an Ewa field of solid H 109, 400 tassels of H 109 were cut from which only two seedlings of any value were obtained; on the other hand, 150 tassels of H 109 cut on the same day in Waipio field O, where other varieties were blooming at the same time, gave 45 strong seedlings, showing a ratio of 5 to 300 seedlings per 1,000 tassels. On December 8, 1922, in Ewa field 25A, 135 tassels of H 109 were cut on the leeward side of other flowering varieties and planted in comparison with 15 tassels of H 109 which had no other variety in bloom to the windward side. Forty seedlings per tassel were obtained from the former while 2 seedlings germinated per tassel of the latter, giving a ratio of 20 to 1.

Tasseling Season

The tasseling season opened November 1, 1922, and closed about the middle of January, 1923, a period of two and one-half months. In general, the tassels appeared in the following order:

H 1801
H 5978
D 1135
Lahaina
H 109
Striped Mexican
Yellow Caledonia
Badila and Uba

The time of tasseling was affected by the vigor of the cane. Sticks that had made good growth tasseled earlier than the stunted sticks, but those that had been very much forced failed to tassel entirely. More and earlier tassels appeared along the ditches, and the leeward edge of the fields, than elsewhere.

Cutting Tassels

Cane tassels take about a month to ripen after appearance, as shown by the following averages:

	Tip of Tassel.	Middle	Bottom
Emergence	1st day	7th day	10th day
Pollen sacks opened	7th day	10th day	12th day
Stigmas opened	9th day	12th day	15th day
Ripened	24th day	27th day	30th day

Each variety had its own peculiarity in this respect, but there was not much deviation from the above table.

Tassels were deemed ripe when the fuzz would fly away at a gentle shaking, and the stems of the tassels developed straw yellow when the tassels became ripe. This change of color was not noticeable in red canes like D 1135, Badila, and Red Tip. Young tassels appeared pinkish on account of the presence of active stigmas; when dried, the tassels became whiter. When in doubt a small quantity of the fuzz was rolled forcibly in the palms of the hands and examined with

a pocket magnifier of 8 to 20 diameters, to see whether or not the seeds had dried enough to resist crushing. This method was also applicable in determining, roughly, the quantity and quality of the seeds present in the tassels.

The cutting party was composed of two men, equipped with an eight-foot trimming pole, a number of empty flour sacks that had previously been washed clean and dried, a number of shipping tags, twine, a note book, etc. One man cut the tassels at a point about a foot below the lowest fuzz branch, and the other man collected five to ten tassels, in each sack. If the tassels were cut a trifle too green, low cutting, that is, one or two joints left on the tassel, would help maturing. On the other hand, if the tassels happened to be overripe, fuzz only could be collected in the field. The sacks containing the tassels were hung in an airy room and dried for from one to three days.

Immediately after a shower the standing tassels in a field remained closed, so much so that it was extremely difficult to observe whether or not the tassels were ripe enough for cutting. Moreover, the very wet tassels often heated up and became moldy in the sacks, without properly drying. If the wet tassels have to be cut they should be hung in small bundles, or loosely, in a well ventilated room.

Early Tassels vs. Late Tassels

Effort was made to obtain an abundant supply of tassels as early as possible, partly to speed up the seedling work and partly to insure successful germination by increasing the chances of trying out a large number of sample tassels. Tassels standing in a field are subject to the disastrous rain and wind storms which usually occur towards the middle or the latter part of the tasseling season. If an approaching storm could be foretold, tassels should be hastily collected, even if a trifle too green. Germination from the earliest tassels was by far the best, from the standpoints of both vigor and number of seedlings.

Tassels Collected For 1923 Oahu Propagation

Lot No.	Parent Cane	Plantation.	Date Cut.	Number of Tassels Cut.
1	H 1801	Makiki	Nov. 22	5
2	"	"	" 23	60
3	"	"	" 23	25
4	"	"	" 24	77
5	"	"	" 24	8
6	"	"	" 28	243
7	H 8901	"	" 28	1
8	H 8910	"	" 28	12
9	H 8913	"	" 28	4
10	H 8991	"	" 28	1
11	H 89102	"	" 28	1
12	D 1135	Aiea, Field 12	" 30	173
13	H 5978	Makiki	" 29	73
14	Str. H. 109	"	" 29	12
15	H 8901	"	Dec. 2	3
16	H 8910	"	" 2	5
17	H 8911	"	" 2	3

Lot No.	Parent Cane	Aiea, Field 12 Makiki	Date Cut. Dec. 2	Number of Tassels Cut.
18	H 8961	"	" 2	2
19	H 8994	"	" 2	5
20	H 109	Ewa 25A	" 3	15
21	H 109	"	" 3	18
22	Str. Mex.	Manoa	" 5	15
23	H 8901	Makiki	" 6	3
24	H 8929	"	" 6	9
25	H 8949	"	" 6	1
26	H 8961	"	" 6	3
27	H 8994	"	" 6	19
28	H 8913	"	" 6	7
29	H 8952	"	" 6	11
30	D 1135	Aiea 12	" 6	225
31	H 8985	Makiki	" 7	7
32	H 8988	"	" 7	6
33	H 8991	"	" 7	12
34	H 89102	"	" 7	11
35	Kea	"	" 8	3
36	"Molokai"	"	" 8	3

Lot No.	Parent Cane.	Plantation.	Date Cut.	Number of Tessels Cut.
37	Laukona	Makiki	Dec. 8	4
38	Pauole	"	" 8	1
39	Papaa	"	" 8	1
40	Akoki	"	" 8	5
41	Palani	"	" 8	4
42	Red Tip	"	" 8	18
43	Unknown Native	"	" 8	2
44	H 109	Ewa 25A	" 8	135
45	H 109	"	" 8	15
46	H 109	Aiea 26	" 8	32
47	H 109	Hawi	Nov. 30	25
48	Str. Mex.	"	Dec. 4	25
49	Str. Tip	"	" 4	25
50	" "	"	" 6	25
51	Badila Sdlg. 110	Manoa	" 11	10
52	1917 O. P. 116	"	" 11	14
53	H 3001	"	" 11	14
54	White Bamboo	"	" 11	30
55	H 109 Pr. 94	Makiki	" 13	15
56	" 63	"	" 13	15
57	" 163	"	" 13	15
58	" 154	"	" 13	15
59	" 155	"	" 13	15
60	" 156	"	" 13	13
61	" 157	"	" 13	15
62	" 78	"	" 13	15
63	" 15	"	" 13	15
64	" 142	"	" 13	15
65	D 1135	Aiea 12	" 13	175
66	White Bamboo	Manoa	" 14	40
67	Rose Bamboo	"	— 14	6
68	H 109	Makiki	" 15	260
69	H 1801	Manoa	" 16	232

Lot No.	Parent Cane.	Plantation	Date Cut.	Number of Tassels Cut.
70	Lahaina	Aiea 26	" 17	371
71	H 109	"	" 17	391
72	D 1135	Aiea 12	" 17	415
73	H 109	Makiki	" 18	630
74	H 109	"	" 19	400
75	Kea	"	" 20	8
76	Laukona	"	" 20	7
77	Red Tip	"	" 20	8
78	Unknown Native	"	" 20	2
79	H 8961	"	" 20	5
80	H 8988	"	" 20	3
81	H 8995	"	" 20	6
82	H 89102	"	" 20	6

Lot No.	Parent Cane.	Plantation.	Date Cut.	Number of Tassels Cut.
83	La. Purple	Hawi	Dec. 19	25
84	Str. Tip	Hawi 1	" 14	100
85	Str. Mex.	Hawi 5	" 19	25
86	Str. Tip	Kohala P 2	" 18	30
87	D 1135	"	" 18	120
88	Str. Mex.	Hawi 5	" 19	136
89	Str. Tip	"	" 21	145
90	" "	Hawi 1	" 21	155
91	Rose Bamboo	Manoa	" 22	9
92	Str. Mex.	"	" 22	4
93	H 3001	"	" 22	24
94	Badila	Ewa 25A	" 28	11
95	Uba	Fed. Exp. Station	" 28	1
96	H 9802	Manoa	" 28	12
97	Badila	Ewa 25A	Jan. 2	2
98	Uba	Fed. Exp. Station	" 2	1
99	"	Makiki	" 3	2
100	Badila	Ewa 25A	" 3	3
101	"	"	" 3	7
102	Str. Mex.	Waipio	" 4	33
103	Badila	Ewa 25A	" 6	16
104	Uba	Makiki	" 9	2
105	"	"	" 15	3
106	"	"	" 22	3

Separating the Fuzz

A sack was kept open by stretching the mouth with a few hooks. Into this were introduced one or two dry tassels, which were spun fast by rolling the stems between the hands. The fuzz would fly off easily if the tassels were dry enough. Of course, the seeds would germinate without first drying, but subsequent handling would be difficult if seedlings were allowed to germinate on long branches of the tassels. The sacks containing the fuzz were properly labeled tied was not satisfactory, because of the confusion that might follow when two and hung on hooks. Attaching the labels to the twine with which the sack was or more sacks were opened at the same time. Labels were sewed to the sacks and separate pieces of twine were used for tying.

Preparation For Planting Fuzz

Soil Mixture. At Makiki a mixture of two parts garden soil and one part coral sand was used. The soil had been steamed for forty-five minutes and the sand had been washed three times, and then steamed for the same length of time. It was found imperative for the soil to be rich and mellow, to assure success. (On one occasion the street car track was laid about the time of this seedling work and a quantity of the soil dug up by the track layers was tested, with very poor results.) In this connection it may be of interest to report that bare seeds were easily germinated on a filter paper moistened with distilled water and kept in a moist chamber. Seedlings grown in this way died, of course, in a few days after coming up.

Flats. Flats were 12¾" wide, 24¼" long, 2¾" deep, inside dimensions, made out of box shooks of spruce. A flat required 1 piece 13¾"x26"x½", 2 pieces 12¾"x2¾"x⅞" and 2 pieces 2¾"x26"x½". Nine holes, one-half inch in diameter, were drilled in each bottom for drainage. These flats were sterilized in boiling water before use. At the same time, small pieces of burlap, say two inches wide and about a foot long, were boiled.

Fuzz Bed. The holes in the bottoms of the flats were covered with the burlap and then enough soil mixture was put into the flats to bring the leveled surface of the soil mixture about one inch below the edge of the flats. The fuzz bed was prepared as needed.

Planting Shed. A shed, or enclosure, was built to ward off the wind. The cane fuzz that would subsequently be handled in here was so light that it would be blown away with the slightest breeze. In this enclosure was constructed a crude table about two and one-half feet high. The ground should stand much water without becoming muddy, hence part of a lawn was used.

Tools Needed. A rubber hose with a fine sprayer nozzle having a provision for stopping the water, wooden labels, brads, pencils, hammer, and towels, were provided.

Planting

A few flats containing the prepared soil mixture were placed on the planting table. A little water was sprayed in a fine mist onto the soil mixture, to make the surface moist enough to hold the cane fuzz. About one and one-half ounces of cane fuzz, representing three to six tassels, were spread evenly on one flat. Water was sprayed on, in a fine mist, until the fuzz became fully saturated, then the fuzz was tapped down lightly with the back or the palm of the hand, and more water was sprayed on, to assure thorough moistening. The flat, after having been labeled with the date of planting, the parentage of the tassels, and the lot number, was taken to a covered frame for germination.

The following method gave excellent results with a small quantity of threshed seeds for the purpose of studying the manner of sprouting the cane seedlings. This was handled by the pineapple specialists along the lines that pineapple seed are handled.

Object: To germinate cane seed.

Sugar cane seed magnified thirty diameters.
Variety H 109

Apparatus: Moist chambers, two sizes, one to be used as platform in larger one, filter paper, blotting paper, cotton, distilled water, tap water, $Hg\ CI_2$, 3 beakers, tweezers.

Method: (1) Cut blotting paper the size of moist chamber and notch the edges.

(2) Heat blotting paper and filter paper in oven for one hour at 100° C.

(3) Sterilize moist chambers with $Hg\ CI_2$ (using small piece of cotton) wash them off thoroughly with tap water, then with distilled water.

(4) Fill a small beaker with distilled water.

(5) Place the cane seed in the beaker of distilled water and wash thoroughly by stirring with glass rod. Pour off this distilled water and add more. Repeat three times, leaving seed in the last water.

(6) Take dishes, paper and beaker of seeds into the pathological transfer room and complete operations, 7, 8, 9, 10 and 11.

(7) Put the sterilized blotting paper obtained in operation 2 on the inside inverted dish, with edges turned down, then place the filter paper on top of the blotting paper.

(8) Pour some distilled water in moist chamber around edge of blotting paper.

(9) Pour off the distilled water from the seeds and empty them out on the filter paper in the middle of the moist chamber.

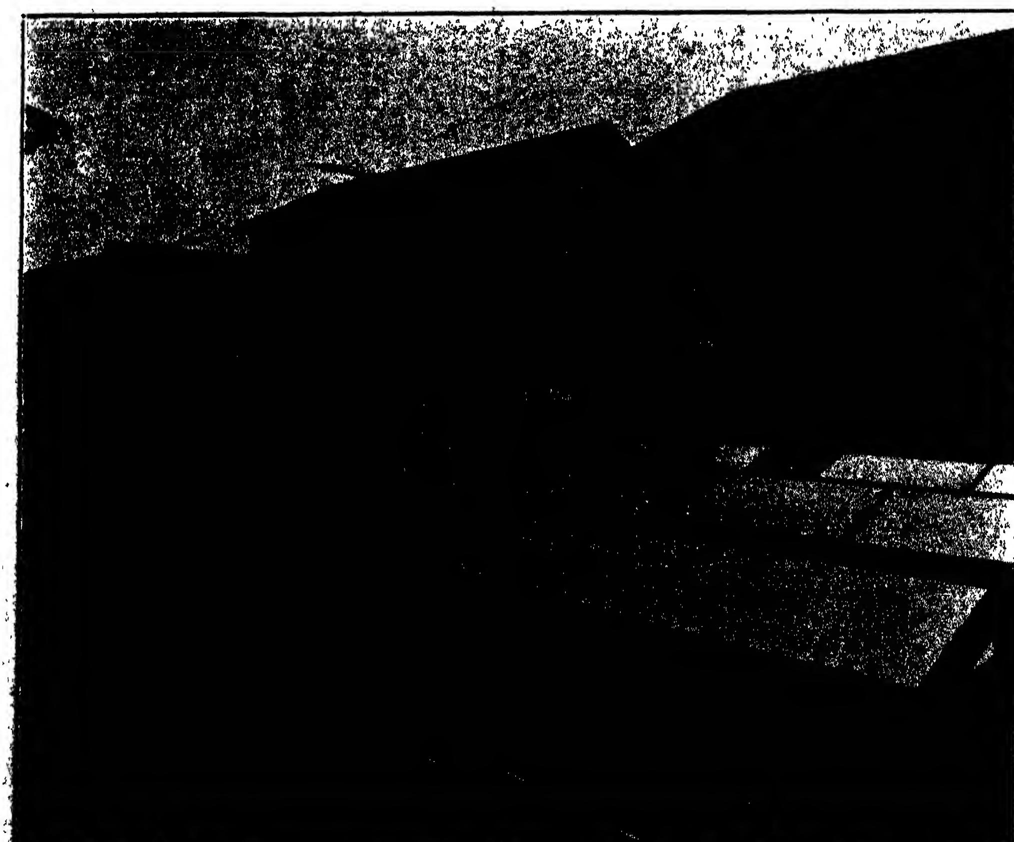
(10) Arrange the seeds on the filter paper in the dish, using tweezers, about ¼ to ½ inch apart.

(11) Place cover on moist chamber.

(12) Place covered dish on shelf in glass-house out of direct rays of the sun.

GERMINATING FRAMES

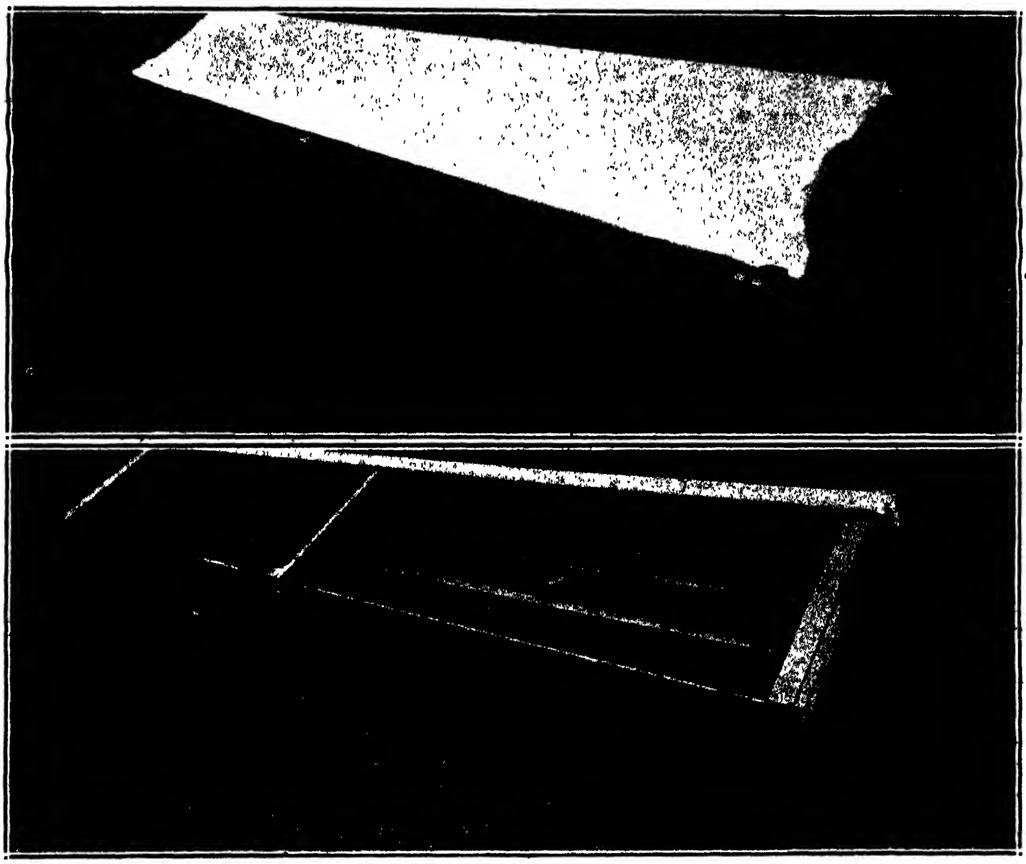
The germinating frames were very simple cold frames, made in two styles. One style had a detachable cheesecloth cover below and a glass cover on top; the other style had an unbleached cotton cover that could be rolled up. The covers in both cases were made at a pitch of about six inches or more per foot to shed rain easily. In the frames were several 2x3 strips laid in such a manner as to hold the fuzz flats about two inches above ground. Frames set on the ground were found to be just as good as those that were set about two and one-half feet above the ground.



Equipment used in germinating cane seedlings. Adequate exposure to sunlight combined with protection from heavy showers and winds has proved a very successful policy.

Water was applied to the fuzz flats in a fine spray, usually twice a day, morning and evening. The amount of water was somewhat regulated by the prevailing weather conditions.

Whenever there was a sign of rain, wind, or very bright sunlight, and always at the close of the day's work, all the germination frames were covered properly for protection. Mere covering was not enough to protect the fuzz flats during the wind storm of January, 1923, and consequently the covers had to be fastened down so firmly that there were no loose ends to flap across the surface of the fuzz, nor glass covers to fly away. In a case of this kind it would be advisable to carry the flats into a substantial greenhouse.



Frame for holding seedling flats, showing awning raised and lowered.

Germination

In from three to fifteen days, commonly four to seven days, tiny white specks appear which quickly turn green. The seedlings at this age were too small to be easily visible from above, but when the surface of the fuzz was seen across, the tiny sugar cane plants made their presence known without difficulty.

Towards the middle of January, 1923, fairly cool weather prevailed, which retarded the germination very much, and heating of the fuzz flats up to 35° C was tried with good success. The "incubation" period, that is the duration of time between the planting of the fuzz and the germination of it, seemed to be much affected by the prevailing temperature and by the age and variety of the

them down if necessary. Every evening all the frames were closed to avoid unexpected accidents during the night.

The flats were irrigated once or twice a day. Sometimes water was cut off entirely for one or two days, depending upon the weather conditions. About three and one-half grams of ammonium sulphate dissolved in 150 c.c. of tap water was applied to each flat about a week after transplanting. Weeds, damping off fungus, and cutworms, began to infest the flats. The weeds were controlled by hand picking, but the fungus and cutworms were held down chemically by the following methods:

Blue Green Algae and Damping Off Fungi

Blue green algae are blue green slimy algae that grow on flats and afford an ideal protection for the starting of damping off fungi. The latter attack the parts of the seedling below the surface of the soil. To check these, apply the following Bordeaux mixture to the soil surface:

3 pounds quicklime,
3 pounds copper sulphate, commercial,
50 gallons water.

Dissolve quicklime in 2 or 3 gallons of water. Dissolve copper sulphate also in 2 or 3 gallons of water. Whenever the spray is needed dilute the quicklime solution with water to 50 gallons less the amount of copper sulphate solution. If copper sulphate solution is 3 gallons, 50 gallons less 3 gallons, or 47 gallons, is the volume of the diluted quicklime solution. Into this diluted quicklime solution add the copper sulphate solution in a small stream keeping the diluted quicklime solution stirred. The stock solutions keep well, but the diluted Bordeaux mixture as made above does not retain its effectiveness long.

Cutworms

Small nocturnal moths fly to objects near the cane seedling flats and deposit eggs in batches covered with grey hair. The eggs hatch in about a week into very tiny cutworms, green or black in color and very difficult to see on cane seedlings. Sometimes the worms migrate into seedling flats from the surrounding weeds. They chew the seedlings voraciously. If a seedling is found eaten a worm can be found not very far from the spot. The worms fall off when the seedlings are touched, and therefore they can easily be caught and killed.

A mixture of 45 grams of electro lead arsenate with five gallons of water is very effective against the worms. It is sprayed in a fine mist onto the seedlings. It is well to keep the mixture agitated because the lead arsenate settles down quickly. The spray must be repeated as new leaves grow up.

Whenever the moths and the egg masses are found they should be destroyed.

Potting

Four to six weeks after transplanting, the seedlings that had reached a height of three inches or more were potted in paper pots containing a good soil mixture.

If there were only a few seedlings resulting from one lot of tassels, they were transplanted directly from the fuzz flats into pots. Some of the seedlings that had made a good growth in the fuzz flats were put into the ground, abridging the intervening transplanting, and gave good results.

Most of the seedlings raised at Makiki were sent away in the transplant flats.

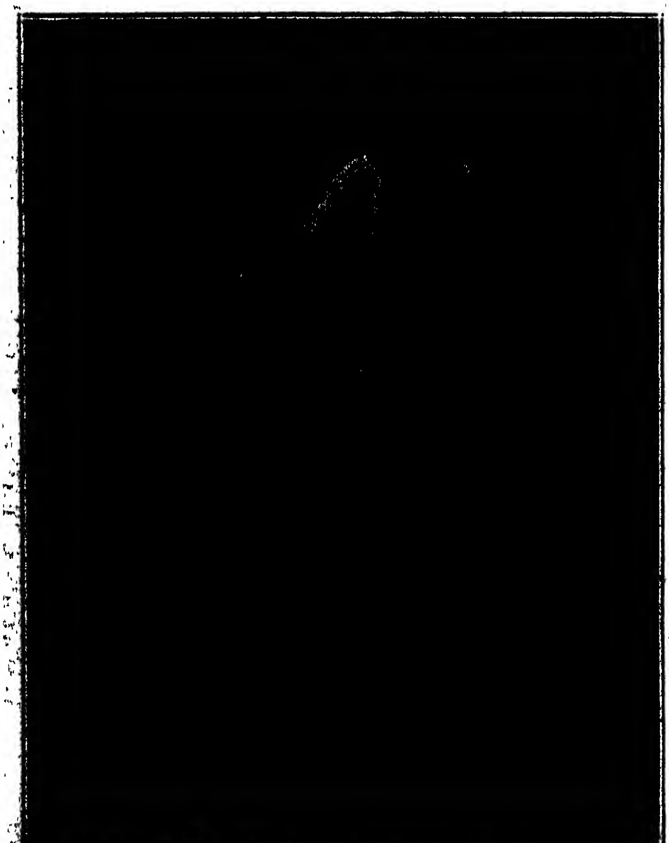
The bed of seedlings in the foreground contains plants that were placed directly into the ground instead of first being planted in pots. Some of these were transplanted directly after germination and part of them were first transplanted to flats.

Paper Pots

Paper pots were introduced in 1917, when there were more cane seedlings to be handled than the number of clay pots on hand, and gradually paper pots replaced clay pots. The pots now used are made of saturated asphalt felt No. 2. The 36-inch rolls are cut into rolls six inches wide, with a band saw. Gasoline is squirted on the band saw to prevent binding. The six-inch rolls are mounted on the cutter and cut into strips 6 inches wide and 15 inches long, these being made into tubes six inches high and about four and one-half inches across. Two paper clips are used on each pot to hold the lap together. No bottoms are attached to these.

Soil Mixture

At Vineyard Street Nursery, a soil mixture of 50 per cent soil, 25 per cent stable manure, 20 per cent leaf mold, and 5 per cent volcanic ash, was used for potting, with great success. At Makiki a mixture of two parts garden soil, one part leaf mold, and one part coral sand gave moderate success. At Manoa straight soil of rather coarse texture was used with fair success. At other places a heavy adobe soil used in the pots made the growth of the seedlings very difficult. Soil suitable for this work should be fertile, draining well, and porous enough to keep good tilth.



Device for cutting paper to be used in making pots for seedlings.

Potting Out

About a week before potting, the soil in the transplant flats was cut two ways among the rows of seedlings, separating each seedling in the middle of a block of soil, and immediately, or one day prior to potting, all the seedlings that had grown three inches or more in height were trimmed of the leaves.

The pots were set in rows on a level spot. Cane trash was put in the bottoms of the pots to assure good drainage. The pots were half filled with the soil mixture. A seedling with a block of soil attached was lifted from the trans-

plant flat, with the help of a putty knife, and was set in the half-full pots. More soil mixture was added, to fill the pot to about half an inch below the upper edge. Water was given immediately, and was afterwards applied once a day. If the potted seedlings showed distress they should be shaded for a while.

A week to ten days later about one-half a gram of ammonium sulphate was applied with a wooden mustard spoon. Another dose followed this if the seedlings did not make sufficient progress.

Cane seedlings in paper pots.

Planting in Field

In six to ten weeks the potted seedlings grew to a height of one to one and one-half feet, a size suitable for planting in the field.

Furrows were made in the field, four to five and one-half feet apart, according to the standard practice of the plantation in which the first field test was to be made. Holes six inches in diameter and about six inches deep were dug, two to two and one-half feet apart, in the bottom of the furrows. The potted seedlings that had been trimmed, if necessary, and amply irrigated, were set in these holes, then the paper pots were opened very carefully to prevent sudden disturbance to the root system and the adhering soil. The empty paper pots with the paper clips which were in good condition, were gathered together to be used again.

About an ounce of ammonium sulphate or nitrate of soda was often applied in the bottom of the holes, previous to planting the seedlings.

Immediately after planting, a liberal irrigation was given, without fail. In fields where irrigation water was not available a rainy day was always utilized for the planting of the seedlings. If the seedlings showed the least sign of drying, that is rolling up of leaves, water was applied promptly.

One or two cuttings were planted here and there throughout the seedling area, for the purpose of comparing the habit of growth with the standard cane.

General Observations

The heavy germination of the seedlings during this season was largely due to the favorable weather conditions which have occurred but once since 1913. In the following table the weather conditions for the month of December only, from 1913 to 1922, are given, since the bulk of the germination was obtained in that month for the propagation of the ensuing year.

Weather Record For December of the Previous Year at Honolulu

Propagation Year.	Mean Monthly Temperature Deg. F.	Total Rainfall Inches.	Total Wind Movement Miles.	Highest Velocity of Wind. Miles per Hour and Date.	Total Number Seedlings Planted in Fields
1913	74.0	2.09	6373	32 on 23rd	3684
1914	72.4	0.52	7269	32 on 5th	1275
1915	71.1	4.37	5268	34 on 19th	4720
1916	73.2	9.18	6187	41 on 25th	613
1917	72.4	5.54	6820	34 on 10th	3295
1918	73.4	4.64	5789	31 on 27th	10154
1919	73.1	4.96	8092	53 on 3rd	9002
1920	73.4	0.90	5472	37 on 3rd	7891
1921	73.7	8.72	6075	37 on 7th	48
1922	72.6	6.12	6355	35 on 13th	1045
1923	73.7	0.66	4996	26 on 3rd	70000

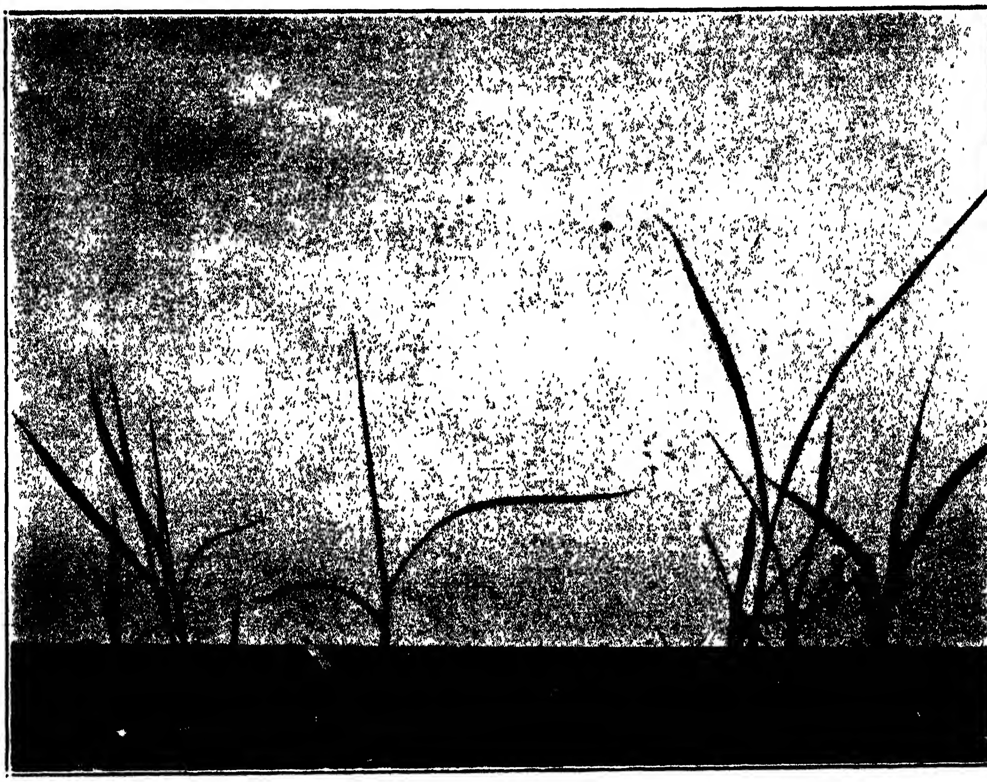
A constant strong wind, as well as a strong gale at a critical moment, seems to have checked seedling work on many occasions.

Spontaneous Seedlings

A field road was plowed about the middle of December, 1922. The surrounding cane tassels were shaking off about then and the seeds must have fallen on the plowed area, because with the heavy rain of January, 1923, about two thousand young cane seedlings sprang up over the road, spontaneously. Although their parentages were totally unknown, about a thousand of them were transplanted into pots. During previous years occasional seedlings have been noted, growing along ditches and around leaky hydrants, but there had not been the opportunity for obtaining so many natural seedlings as during this season.

Green Tassels

A patch of Badila was in flower on the leeward side of H 109, which had flowered a little earlier than the Badila. The prospect for obtaining crosses between Badila and H 109 was very good indeed, but the plantation had to harvest the Badila about ten days before the tassels could ripen. In order to save the tassels the following methods were tried:



Voluntary seedlings of sugar cane which sprung up by thousands.

(a) Tassels were cut with about a yard of the stalks left on; they were carried to a nearby ditch, the cut end was again cut under water, and the tassels were left standing in the running water.

(b) Some stools with tassels were dug with a good deal of adhering soil and left standing in a ditch.

(c) Some tassels were cut as in (a), but instead of leaving them in the ditch they were transported about 20 miles and kept standing in a tank, in which the water was changed daily.

(d) Some stools were dug as in (b) and transplanted in a field some 20 miles away.

All the tassels obtained from the above four lots failed to germinate.

Special Seedlings

The latter part of November, 1922, the tassels of Uba* began to emerge at the Federal Experiment Station field, and a few days later, probably December 2 or 3, the Uba in Makiki field began arrowing. Windbreaks were built around the flowering Uba at the two stations in order to protect the delicate tassels from the action of violent winter storms.

About twenty young tassels were brought in to Makiki from Oahu Sugar Company fields once every two or three days for supplying pollen grains, to be dusted on the Uba tassels. The D 1135 tassels were cut with one to two feet of the stalks before the opening of the stigmas; the cut ends were either wrapped in moist towels or inserted in a bucket of water; the tassels were covered and tied and carefully carried to the Makiki laboratory. At Makiki the cut ends of the stalks were cut under water, and the tassels were left leaning against a table in a quiet but well ventilated room. In one to three days the pollen grains were shed, which were caught on glazed black paper spread on the table and under the tassels. The pollen grains were brushed into a cup having a cover, taken out to the field and the Uba tassels with the open stigmas were literally painted with the pollen grains by means of a soft brush. This work was in cooperation with Dr. L. O. Kunkel.

Results of Uba Tassels

Lot No.	No. of Tassels	Date Planted	Date Germinated	No. Germinated
95	2	Dec. 29	Jan. 6	2
98	1	Jan. 3	....	....
99	2	" 5	....	....
104	2	" 12	Jan. 28	3
105	3	" 16	" 26	7
106	3	" 26	Feb. 20	2

The fuzz flats were heated for a considerable time during the cold spell of January, with good results, especially with lot number 105.

The Uba seedlings were extremely delicate and did not stand handling well. Five seedlings only were successfully planted out to the field at Makiki. They were: one from lot number 104 and four from lot number 105.

Closing Remarks

Tasseling season might last three months, but collecting season could not be much longer than three weeks, during which time the slang "Get it while the getting is good" applies with particular force to cutting tassels, because no amount of effort and painstaking care could, according to experience, overcome the insufficient supply of tassels for seedling work.

* The so-called Uba of Hawaii. This has not been positively identified as the same as the Uba of Natal.

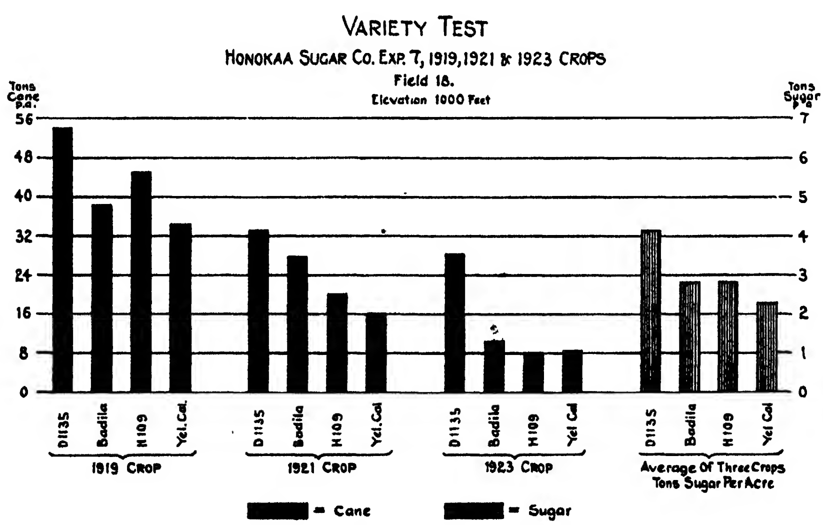
Cane Varieties in Hamakua.

Honokaa Sugar Co. Exp. No. 7, 1919, 1921 and 1923 Crops.

In this test a comparison was made between D 1135, H 109, Yellow Caledonia, and Badila. Three crops have been harvested, one plant and two ratoon. The experiment is located in field 18 at an elevation of 1,000 feet, and is just makai of the government road, near the Honokaa village. The field is not irrigated. The 1919 and 1921 crops were 25 months old when harvested, and the 1923 crop was 19 months old.

The results obtained are given in the following table:

Variety	Tons Cane per Acre. 1919 Crop.	1921 Crop.	1923 Crop.	Average Q. R.	Total Tons Sugar from Three Crops
D 1135	54.1	33.2	28.3	9.26	12.48
H 109	45.0	21.6	8.2	8.74	9.56
Badila	38.4	27.9	10.5	9.05	8.49
Yellow Caledonia	34.5	16.1	8.6	8.53	6.94



The above results show D 1135 to be far superior to any of the other varieties. This is especially the case in the ratoon crops. In the second ratoon crop the other three varieties were practically complete failures while D 1135 did pretty well, and on account of its ratooning powers was a much cheaper cane to raise.

As plant cane H 109 did fairly well, producing 45 tons of cane per acre, but it did not ratoon, the last crop producing but 8 tons of cane per acre.

Under adverse conditions D 1135 is showing itself more and more to be our best ratooner up to elevations of about 1,500 feet. We strongly advise all plantations having trouble with their ratoons to give D 1135 a thorough trial if they have not already done so.

Details of Experiment—Variety Test

Object:

Comparing Yellow Caledonia, D 1135, H 109, and Badila.

Location:

Field 18, elevation about 1,000 feet.

Crop:

Second ratoons long, previous crop harvested July, 1921.

Layout:

Number of plots: 38.

Size of plots: 1/10 acre each, consisting of 6 lines, each row 4½' wide and 161 1/3' long.

Plan:

Fertilization uniform to all plots same as to the rest of the field, to be done by plantation.

J. A. V.

Thinning Sugar Cane.

By J. A. Verret

It is a well known fact that a field of cane three to six months old contains many more cane stalks than will be found at harvest. A field of mature cane hardly ever contains more than three stalks of cane per running foot of row. The average is generally below three. In young cane one finds eight to ten stalks or more per running foot. Some of these stalks attain fairly large size before dying. These stalks use up plant food while living and are growing in competition with the stalks which are to live to maturity. It would, therefore, seem logical to suppose that if these stalks were prevented from growing at all, the original stalks, not having so much competition, would have a larger growth and increase the final yield of the field. These cane stalks, which grow a few months and then die, must have the same effect that an equal amount of weeds would have.

Recently a visitor to the Station, from Formosa, stated to the writer that it is the practice there to cut out about 30 per cent of the young cane shoots during the second hoeing. That would be in cane two to three months old.

With the idea of trying out the value of thinning sugar cane in an experimental way, a small test was conducted here at Makiki. For this purpose an area consisting of seventeen lines was used. The cane was first ratoons. The original planting was from one-eye seed, spaced two feet in the row. When harvested at the age of twelve months, this plant cane had 6.77 stalks per stool, or 3.38 stalks per running foot. When four months old, this same cane had about eighteen stalks per stool.

In conducting this experiment the ratoons were thinned down to eight stalks per stool, this being done when the cane was three months old. The eight largest stalks in each stool were kept and the others cut away. Any new shoots appearing were destroyed. The check plots were allowed to grow in a natural way.

The cane was harvested when twelve months old. The results showed a loss from thinning as indicated in the following tabulation:

Treatment.	Tons Cane per Acre.	Av. No. of Stalks per Foot.	Av. No. of Stalks per Stool.	Av. Weight per Stalk.	Av. Weight per Foot.
Not thinned................	55.7	3.90	7.80	3.31	12.90
Thinned....................	50.5	3.52	7.04	3.34	11.75

The above results show a difference of five tons of cane per acre in favor of not thinning. This difference in yield is due to the fact that the thinned area had less stalks of cane at harvest. Although the stalks in the thinned area were slightly heavier, .03 pound per stalk, it was not enough to make up for the lesser number present. In the thinned area we harvested 7.04 stalks per stool, the mortality after thinning being 12.5 per cent. In the unthinned area the mortality was 50 per cent. It is possible that different results would have been obtained had the thinning not been so severe. We plan to repeat the test along these lines, leaving, say, five stalks per foot instead of four.

The Availability of Iron in Manganiferous Soils

By W. T. McGeorge

Plants which do not make normal growth often develop a chlorotic condition of the leaves usually attributed to certain nutritional disturbances. Such a condition is more often noted on calcareous soils although other factors have been cited. Of the latter the chlorosis of pineapple leaves on plants grown on the manganiferous soils of Hawaii is an example.

In an investigation of these manganiferous areas and the nutritional disturbances of numerous plants grown on these soil types, Kelley (1) has reached the following conclusions: "From these evidences we may believe that the effects of manganese are largely indirect and are to be explained on the basis of its bringing about a modification in the osmotic absorption of lime and magnesia, and that the toxic effects are chiefly brought about through this modification rather than a direct effect of the manganese itself. * * * The per cent of lime is increased while the absorption of magnesium and phosphoric acid is decreased * * * ; in practically every instance a modification of the mineral balance was observed and this was found to follow the same direction * * * regardless of whether the plant showed a toxic effect."

Gile (2) has noted a development of chlorosis on pineapple plants grown on calcareous soils in Porto Rico. He found the application of iron salts to the leaves to be very effective and to induce normal growth.

Johnson (3) on the basis of Gile's work applied solutions of iron salts to the leaves of pineapple plants suffering from chlorosis on the manganiferous areas in Hawaii and noted a return of the plant to normal growth. While he appears to have published no record of laboratory investigations he concluded that the chlorosis was due to a locking up of the iron by the manganese in an unavailable form in the soil. By a recalculation of a selected part of Kelley's data he then

proceeded to substantiate his interpretation by showing a lower iron content in those plants which had become chlorotic. A study of Kelley's data in toto (1) does not indicate such to be true. The iron content of the ash of all plants analyzed shows considerable variation but no consistent relation to the manganese content of the soil. This is especially true of the pineapple plant of which Kelley made four analyses and of which only one, that cited by Johnson, showed an appreciably lower iron content in the plant grown on manganese soil as compared to that grown on a normal soil.

In a recent study on the nature of acidity in Hawaiian soils, the writer has noted certain peculiarities which may throw some light on the chlorosis of pineapple leaves grown on these manganiferous areas. Hawaiian soils, while characteristically basic, that is very high in iron, aluminum and manganese oxides, which are often in excess of silica, are usually acid in reaction. The iron content of these soils, expressed as Fe_2O_3, varies greatly and usually falls within the range of 20-40 per cent. This is true of the manganiferous areas as well as other types.

In a study of the relative acidity in manganiferous and non-manganiferous types samples of soil and subsoil were taken representing both types. The acidity expressed as pH is given in the following table:

TABLE 1.

Showing Acidity of Two Soil Types Expressed as pH.*

Soil No.	$\%Mn_3O_4$ Soil.	pH Soil.	$\%Mn_3O_4$ Subsoil.	pH Subsoil.
1. Manganiferous	7.3	5.9	3.5	6.5
2. "	4.5	5.9	3.0	6.7
3. "	4.7	6.0	3.9	6.7
4 Non-manganiferous.......	..	6.6	..	6.5
5 "	..	5.9	..	6.1
6. "	..	4.5	..	4.3

The manganese content of the non-manganiferous samples was not determined, but soils from the locality usually contain less than .5 per cent. The characteristic color of the manganese type is a chocolate brown, changing to a red subsoil at eight to twelve inches. The lower manganese content of the subsoil is typical. The above subsoil samples represent the depth below change of color to two feet. With change of color there is also a notable change in physical texture, the top soil being much more granular or, better, more silty. This may be attributed to the deposition of manganese upon the soil grains thereby increasing their size. It is typical of the manganese type that the manganese is present as MnO_2 in the form of concretions or deposited as a film on the surface of the soil grains.

* In expressing soil reaction in terms of pH, water being practically neutral is assigned a value of pH 7.0 (neutrality). Values below 7 indicate acidity, diminishing pH increasing acidity, our most acid soils being about 4.5. Values above 7 indicate an alkaline soil.

The interreaction between metallic elements in solution is governed theoretically, at least, by their relative positions in the electromotive series, each element replacing another standing lower in the series until a certain equilibrium is reached. The relative position of the more important elements present in the soil is as follows; potassium, sodium, calcium, magnesium, aluminum, manganese, iron. It must be admitted, however, that in a soil other factors such as hydrolytic action, basic replacement, and double decomposition must be considered. Yet it is evident from the above that iron standing lowest in the series should be present in less concentration in the soil solution and that calcium and aluminum should exercise a greater displacing action than manganese, being higher in the series, and should further displace manganese itself.

In studying the relative solubility of iron and manganese in these acid soils it was found that iron salts were present in highest concentration in those soils of pH 5.5 or lower; that manganese is a factor principally in those soils of pH 5.5 or higher. This applies to all types regardless of the actual manganese present in the soil, that is whether high or low.

Now, with commercially grown crops here in the Islands, those which appear to produce normal growth on highly calcareous soils also grow with least disturbance on the manganiferous types. Reference is made to sugar cane and sisal *(Agave Sisalana),* more particularly the latter. Until a recent date there were two sisal plantations on the island of Oahu. One was located in the coral areas practically devoid of soil, and the other in the heart of the manganiferous areas. Plants grew normally in both but slightly better on the manganese soil, due to better environment. Johnson has noted (3) that the calciphilous legumes being among the most strongly affected on manganese soils proves this element to be the cause of the chlorotic condition. He fails to point out, however, that Crotolaria, one of the most widely distributed legumes in the Islands, grows luxuriantly on the manganese soils (1). This seems more tenable from Truog's work (5), in which he found all degrees of lime requirement in legumes as well as non-legumes.

Gile (2) found that it was possible to obtain a normal growth of pineapples on a soil containing approximately 30 per cent lime by heavy fertilization with stable manure. Kelley (1) found the same to be true on the manganese soils. The form of manganese present in Hawaiian soils is extremely soluble in organic acids. It hardly seems tenable that the fertility of these soils would be increased by heavy applications of organic fertilizers if the toxicity is due directly to manganese.

In studying the relation of iron, aluminum, manganese, and lime to soil acidity in Hawaiian soils, it was found that as compared to aluminum both iron and managnese appear to be only a small factor in determining the reaction. The aluminum content of these soils is approximately equal to that of iron, but in measuring the solubility in dilute mineral acids and other weak solvents, aluminum is dissolved in considerable excess. This also is in agreement with the respective position of these elements in the electromotive series. Also, there is a direct relation between the solubility of lime and acidity. In the following table is shown the relation between the per cent lime soluble in water saturated with CO_2 (shaking 1 part soil to 5 parts water) and pH:

TABLE 2.

Showing Relation of Lime to pH in Typical Hawaiian Soils

Soil No..........	848	367	399	765	186	621	722	872	3
pH	4.63	4.88	4.97	5.56	5.73	5.98	7.00	7.67	8.01
%CaO	.008	.009	.013	.015	.017	.023	.033	.081	.131

The interpretation seems tenable from the above data that lime is closely related to the concentration of the elements iron, aluminum and manganese in the soil solution of Hawaiian soils. Kelley (1) has shown these manganese areas to be of alluvial origin, the manganese having been brought into solution by leaching, ultimately being deposited in the low lying pockets. This theory is borne out by the sporadic occurrence of the manganese spots which are usually lower than the surrounding non-manganiferous types. Judging from their respective positions in the electromotive series it is evident that the lime present in the soil solution is the principal factor in this deposition of manganese. It is usually present in excess of all other elements in the soil solution and water extracts of Hawaiian soils. This further explains the lower hydrogen ion concentration in the subsoils of manganiferous types. Calcium, replacing manganese in the soil solution, increases the concentration of calcium which, due to the loose texture of this soil type, is easily washed into the subsoil. The humus content of these soils is very low. The hydrogen ion concentrations appear to be due principally to the presence of acid-reacting silicates. The lime is fixed in the subsoil by these acid aluminum silicates forming silicates of lesser acid tendencies. On determining the solubility of lime in CO_2 saturated water, the following results were obtained with the three manganese soils and subsoils:

TABLE 3.

Showing Relation of Solubility of CaO in Soil and Subsoil

	1. Soil.	1. Subsoil.	2. Soil.	2. Subsoil.	3. Soil.	3. Subsoil.
%CaO	.023	.017	.015	.010	.028	.022
pH	5.9	6.5	5.6	6.7	6.0	6.7

These results appear to indicate the presence of silicates of lesser acid tendencies in the subsoil. It will be noted that the solubility in the subsoil is lower than the soil, yet the hydrogen ion concentration is lower. The higher solubility of lime in the manganese soils as compared with the normal red soil is typical. This greater solubility of lime, the activity toward the replacement of manganese in solution as well as aluminum and iron, the open texture and better aeration in such types which assures a ready supply of air and CO_2 for the solution of calcium as bicarbonate, appear to be important factors in the chlorosis of pineapple plants grown on this soil type. It might also be mentioned at this point that pineapple roots are almost entirely confined to the surface soil; also that the development of chlorosis usually follows liming even on the more acid island soils.

Wilcox and Kelley (6) in an anatomical examination of the physiological disturbances in plants grown on manganese soils, noted a superabundance of calcium oxalate crystals in the chlorotic pineapple leaves. The chemical analysis of leaves has also shown a markedly higher lime content as compared to the normal green leaves.

Availability of Iron

Comber (4) has developed a qualitative test for soil acidity in which he shakes the soil with a solution of KSCN in alcohol. By increasing the concentration of $Fe(SCN)_3$ in the liquid phase by the use of this solvent, he obtains a very delicate test for iron, indicating the presence of acid-reacting salts of this element and aluminum. The delicacy of this test is further increased by using an ether-alcohol solvent for the reagent. As thus applied to the manganese soils all showed a positive test for iron in solution. The depth of color is just as great as in the non-manganiferous soils of equal H ion concentration. One difference was noted, however. The color of the test gradually fades in those soils, of pH 6.0 or higher, to a greenish blue. This is due to the presence of manganese as dioxide and not to the presence of manganese salts in solution. This was noted in the normal soils containing as low as .4 per cent MnO_2 and was produced in a soil pf pH 4.3 by the addition of MnO_2 but not by the addition of any amount of manganese salts.

Comber (4) attributes this reaction to a double decomposition, while Carr (7) suggests the actual solution of iron and aluminum which existed previously as colloidal basic salts. In either case the test indicates the presence of iron in readily available form in the manganiferous type and that MnO_2 does not hold the iron in an unavailable combination.

Mobility of Iron

In a very thorough study of the availability of iron and its mobility in the plant, Gile (8, 9, 10, 11) has shown certain factors to greatly influence the mobility of iron in the leaves. He found that chlorotic leaves on calcareous soils when restored to normal color by spraying with iron salts do not transfer this iron to new leaves, but the latter must be sprayed in order to maintain the green color of the plant as a whole. That is to say, with the withering of the old leaves the iron is not transported to the new. In the commercial spraying of pineapple plants in Hawaii, which is successfully practiced on an extensive economic scale, plants grown on all soils show a response to spraying with solutions of ferrous sulphate. Of course, this is most marked on the manganese soils where the chlorotic condition is more prevalent. Also, the spraying must be continued at intervals throughout the life of the plant. These facts clearly indicate the low mobility of iron even in the normal pineapple plants.

Conclusions

It is believed that the foregoing results indicate that the chlorosis of pineapple leaves on plants grown on manganese soils is due to a greater assimilation

of lime indirectly caused by the presence of manganese in excessive amounts in the soil.

The principal physiological disturbance is the greater immobility of iron in the plant resulting from the excessive lime content of the leaves and stalk and the low rate of mobility of iron even in normal pineapple leaves.

Iron is shown to be present in equally available form in both manganiferous and non-manganiferous types of equal hydrogen ion concentration. The fact that the addition of soluble iron salts to the soil is without effect and that new leaves must be sprayed indicates lack of mobility in the plant to be the principal inhibiting factor.

It is not denied that manganese under certain conditions may exert a toxic effect on plants. Numerous references in literature tell of such. This is especially true in water and sand cultures carried on in the absence of the complexities of soil environment. Also, it is recognized that manganese may displace iron in solution in water and sand cultures. The relative positions in the electromotive series proves this, but it also indicates that lime functions as such with relatively greater activity.

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Repairs Under Pressure.*

Two fatal accidents that occurred recently were directly due to the highly dangerous practice of attempting to repair boilers, steam pipes, and other closed vessels and objects while they were under pressure. We have repeatedly warned against this practice and the hazard has often been pointed out in other ways; but the frequency with which accidents from this cause continue to occur is discouraging, and it is evident that this very real danger is often ignored, or at least receives too little consideration.

* Boiler Maker, Vol. XXIII, No. 3.

One of the accidents to which we refer occurred in connection with a water-tube boiler. This boiler is one of a battery, and had been shut down for a time. In the process of putting the boiler in service again, steam had been raised to a pressure of 130 pounds, but the boiler had not been cut in on the line. A leak was discovered around one of the tube-caps in the front water leg, and the attendant tried to "roll in" the cap. The cap was of a somewhat unusual type, and during the operation it was pushed in, and a stream of boiling water under 130 pounds pressure rushed out directly into the attendant's face. The man was hurled against a coal pile about twelve feet distant and almost instantly killed.

In the other case, two men were attempting to stop a leak at the flange of a reducing tee on a steam-pipe line. They had put a packing ring or gasket in place and were tightening the bolts which compress the gasket between the flanges. This caused the steam pipe to pull out of the tee, and the parts separated a distance of about eight inches. The escaping steam blew one of the men off from a timber on which he was standing and into a concrete wheel-pit. The other man was blown from a ladder, but was able to go to the boiler room and have the steam shut off. On returning to the scene of the accident it was found that the first man was fatally scalded. He was removed to a hospital but died within a short time. It is said that previous attempts had been made to stop this same leak, but they had not been successful. It is also stated that the joint was defective, and that to prevent similar accidents in the future, the entire pipe line was soon to be dismantled and examined.

Wherever this article comes to the attention of a man who is accustomed to repair vessels of any kind under pressure, we sincerely hope it may be the means of influencing him to discontinue the practice. We know very well that work of this sort is often done without disastrous results; but there are plenty of examples of fatal cases, and no man who persists in following the practice can tell when his turn may come. Neither has any employer a right to ask a man to risk his life in this way. Delays and shut-downs may cause extra expense, but this should not be considered where human life is endangered.

[W. E. S.]

Sex Proportion in Trapped Rats and Mice.

The following table showing the sexes of rodents trapped on the island of Hawaii from Sept. 1, 1922, to Feb. 28, 1923, is of interest. I have compiled this from the weekly reports of Mr. C. Charlock, Territorial Board of Health. The sex determinations were made under the supervision of Mr. Charlock, upon recommendation of Dr. Trotter, in response to our original request for the information. So far as available literature shows, this is one of the largest sex-ratio determinations ever made on trapped rats. It has generally been assumed that the proportion of sexes is about equal and that in trapping operations more males are caught than females, under the supposition that they are

bolder and more active. The work of Petrie and Macalister in England in 1911 on this point bears out this theory. They found that of 6071 rats collected in January and February, 3273 were males and 2724 females, 74 being unrecorded. The data herein show results entirely opposite. Of 74,941 rodents caught on Hawaii between Sept. 1, 1922, and Feb. 28, 1923, 28,657 were determined as males and 46,284 as females. The explanation of this difference must necessarily be very complex and probably impossible. It is not unreasonable to suppose, however, that the great difference between climate, available food and housing conditions in England and our cane fields, plays a prominent part in this difference in catch.

The data in the table show no wide variations in the sex-ratio from month to month. It covers the warm autumn months and the coldest period of winter. There is also very little difference in the sex-proportion of one species of rodent over another. The results would tend to upset somewhat the Rodier theory of rat-control. If the sexes in the field are nearly equal, the trapping operations are constantly removing many more females than males, yet trapping as a method of economic rodent-control in Hawaii has proven a failure after many years of large operation.

PROPORTION OF SEXES IN TRAPPED RODENTS ON ISLAND OF HAWAII, FROM SEPT. 1, 1922, TO FEB. 28, 1923.

	Rattus norvegicus		Rattus alexandrinus		Rattus rattus		Mus musculus	
Month	Males	Females	Males	Females	Males	Females	Males	Females
Sept., 1922	703	1047	475	784	719	1106	2209	3094
Oct., 1922	663	1043	365	610	986	1551	1948	3272
Nov., 1922	756	1238	250	405	1206	2107	2678	4988
Dec., 1922	676	1285	270	513	1188	2331	3265	5072
Jan., 1923	730	1094	320	503	1346	2490	3177	4708
Feb., 1923	642	890	326	470	1291	1918	2468	3765
Total	4170	6597	2006	3285	6736	11503	15745	24899

Total: All forms ....28,657 Males
" " ....46,284 Females

Rodents trapped from the following localities on the island of Hawaii:

Olaa Sugar Company,
Waiakea Mill Company,
Hilo (city),
Hilo Sugar Company,
Onomea Sugar Company,
Pepeekeo Sugar Company,
Honomu Sugar Company,
Hakalau Plantation Company,
Laupahoehoe Sugar Company,
Laupahoehoe village,
Kaiwiki Sugar Co., Ltd.,
Hamakua Mill Co.,

Kukaiau Sugar Company,
Paauilo village,
Pohakea, Hamakua,
Paauhau Sugar Company,
Honokaa Sugar Company,
Honokaa village,
Pacific Sugar Mill,
Kukuihaele village.

C. E. P.

Sugar Prices.

95° Centrifugals for the Period March 16, 1923 to June 15, 1923.

Date		Per Pound	Per Ton	Remarks
March	19, 1923..	7.34	$146.80	Cubas.
"	20	7.25	145.00	Cubas 7.28, 7.22.
"	21	7.22	144.40	Cubas.
"	23	7.28	145.60	Porto Ricos.
April	5	7.345	146.90	Porto Ricos 7.28, 7.41.
"	6	7.47	149.40	Cubas.
"	9	7.53	150.60	Cubas.
"	10	7.66	153.20	Cubas.
"	11	7.72	154.40	Cubas.
"	12	7.66	153.20	Cubas.
"	17	7.78	155.60	Porto Ricos.
"	18	8.00	160.00	Cubas 7.97, 8.03.
"	20	7.91	158.20	Cubas.
"	23	8.28	165.60	Cubas.
"	26	8.41	168.20	Cubas.
"	27	8.28	165.60	Philippines.
"	30	8.03	160.60	Cubas.
May	3	7.845	156.90	Porto Ricos 7.91; Cubas 7.78.
"	4	7.41	148.20	Spot Cubas.
"	8	7.845	156.90	Porto Ricos 7.78, 7.91.
"	9	8.03	160.60	Porto Ricos.
"	10	8.22	164.40	Cubas 8.22; Porto Ricos 8.28, 8.16.
"	11	8.28	165.60	Porto Ricos.
"	14	7.91	158.20	Spot Cubas.
"	16	7.78	155.60	Porto Ricos.
"	25	8.28	165.60	Cubas.
"	28	8.16	163.20	Philippines.
June	5	8.03	160.60	Porto Ricos.
"	6	8.10	162.00	Porto Ricos.
"	8	7.93	158.60	Cubas 8.03; Spot Cubas 7.91, 7.85.
"	11	7.69	153.80	Philippines 7.66; Spot Cubas 7.72.
"	12	7.66	153.20	Cubas.
"	13	7.405	148.10	Spot Cubas 7.28, 7.53.
	14	7.22	144.40	Spot Cubas 7.16; Cubas 7.28.

THE HAWAIIAN PLANTERS' RECORD

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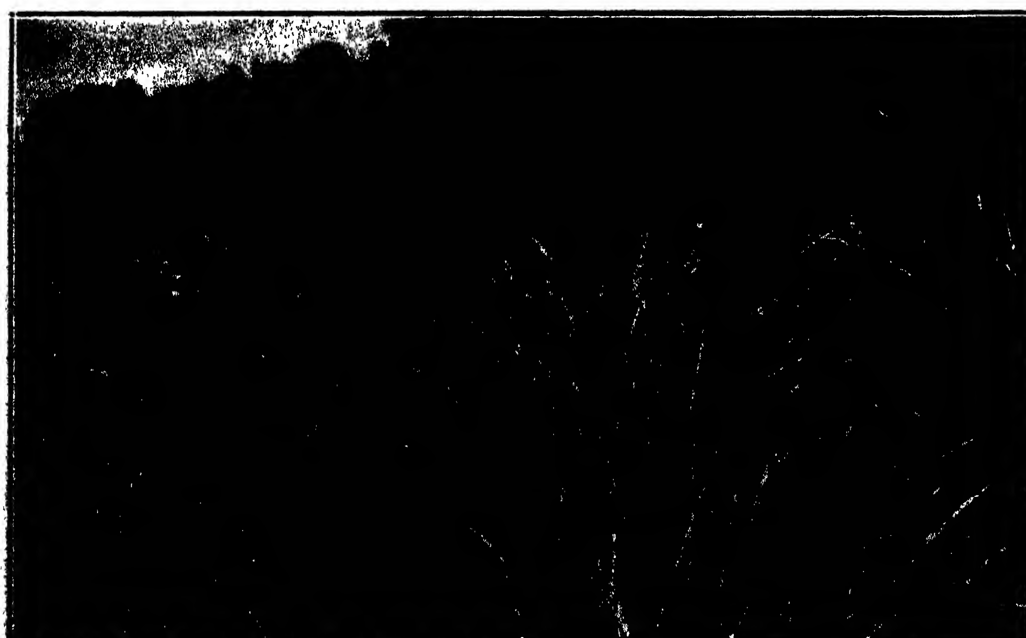
Notes on Armyworms and Cutworms

The accompanying pictures show armyworm and cutworm damage at Honokaa this year. These are of Uba cane and represent the condition of several hundred acres of mostly D 1135 fields. Most of the damage was done to the young cane extending from about 800 feet elevation to the highest fields. This severe check must cause a very considerable retarding effect, for most of the leaf-tissue was removed.

The common armyworm *Cirphis unipuncta* was mostly responsible for the damage. Thousands of the larvae were present on the cane, grass and ground about the fields. The expected second generation from these did not materialize. Moths hatched out in fair quantity, but few eggs were placed on the cane or grass in the cane fields. At present only a single worm at wide intervals can be found.

At the close of the outbreak some of the natural enemies of the caterpillars were conspicuous. The large yellowish *Polistes* wasps were particularly numerous and were very busily skinning the larvae and carrying the partially chewed skins to their paper nests. A few days ago, while riding along the main ditch through young fields of cane, I counted 500 of these wasps passing in front of me in twenty minutes' time. The two important Tachinid parasites *Frontina archippivora* and *Chaetogaedia monticola* have also been numerous, particularly the former. On June 8th I took twelve of the armyworms from the field and placed them in a jar with grass. None matured, but from each one there emerged a *Frontina* maggot after the caterpillar had died.

Several poison-baits were tried by Mr. E. E. Naquin, but only one proved highly successful. Success was obtained with the standard mixture of Paris green and finely powdered air-slacked lime, mixed in the proportion of one part Paris green to eight parts lime and applied to the cane in dry dust form. By partially filling a sugar sack with the mixture and shaking the closed bag over the cane, the dust was very evenly and thoroughly distributed. Most of the larvae present when this was applied died. The Honokaa Sugar Company has now on hand a large stock of the poison to apply in the above method in case of future outbreaks of cutworms and armyworms.



Judging from the results obtained in poisoning with the dust-mixture, I am very much in favor of this method over the old way, where a moist bran or bagasse mash is applied containing the poison. This did not work nearly as well as the dry mixture.

C. E. P.

The Root-Rot Problem Up to Date

By H. L. Lyon.

A malady characterized by the destruction of the root system followed by the collapse of the aerial portion of the plant is known in the pathology of a great many cultivated plants. This malady passes under various names, but "Wilt," "Root disease" and "Root-rot" are the names most often employed. The disease of this nature in pineapples and in cotton is known as "Wilt"; in sugar cane it is called "Root-disease" and "Root-rot".

There is no reason to believe that the cause of root-rot is the same in different species of plants or even that it is always the same in any one species, but a complete understanding of the disease in any species would be of great assistance in the investigation of the similar disease in other plants for it would indicate a line of attack that might be expected to produce results.

In the following pages, we strive to indicate the present status of the root-rot problem by recounting the findings and quoting the opinions of investigators who have recently worked and published on the subject.

Root Disease and Root-rot in Java

In 1895, Wakker described a new soil-dwelling fungus, *Marasmius Sacchari*, which he said was responsible for a disease of sugar cane in Java. There was no doubt but that he found this fungus growing as a parasite on sugar cane plants, attacking their roots and the underground portions of their stalks. The Java planters and their scientific advisers, however, recognized a malady which was distinct from Wakker's "root-stalk" disease because it occurred far more extensively than did *Marasmius* and was not attended by certain symptoms always created by this fungus. In 1898, the Java planters became so alarmed by the widespread occurrence of root-rot that they raised a fund to support an intensive investigation of the malady. Dr. Z. Kamerling was selected to devote all of his time to the study of root-rot and a special root-rot laboratory was created and maintained for several years. During the years 1900 to 1903 inclusive, several papers appeared on root-rot in Java and in the last named year, Kamerling published a book of some two hundred pages on the subject. He suggested that the cause might be poor aeration of the soil, but his main idea seemed to be that the trouble was in some way due to mechanical injury of the roots by the soil particles. His thesis is lacking in tangible evidence and tangible conclusions.

After the publication of Kamerling's work, the investigation of root-rot seems to have lagged in Java for many years, due, no doubt, to the fact that the old Cheribon variety was being replaced by seedlings which were far more resistant to root-rot. In recent years, a seedling cane known as E. K. 28 has become the leading cane variety in Java and now occupies fully 40 per cent of the total cane-growing area in the island. This seedling is very subject to root-rot, however, and in 1921 the disease became so prevalent in E. K. 28 that some expressed fears that the variety would be eliminated altogether. This scare caused many growers

to turn from E. K. 28 to other more resistant varieties in their plantings for the 1922 crop.

In an attempt to reassure the planters and restore the standing of E. K. 28, Dr. J. Kuyper* has recently published a lengthy dissertation, in which he tries to demonstrate that the fear of root-rot in this favored variety is unfounded. He does not seek to do this by definitely proving the cause of root-rot and offering a specific remedy, but strives, by recounting field observations and statistics, to show that the occurrence of root-rot is limited to soils of a certain nature; that it had reached the maximum spread possible in E. K. 28 in 1921; and that even with root-rot present in certain sections E. K. 28 still gave a better average yield than any other variety.

Dr. Kuyper's description of root-rot in Java tallies very closely with the symptoms of the disease as displayed by Lahaina cane in Hawaii. He asserts that the malady occurs in practically all the cane varieties of Java.

Dr. Kuyper seems quite confident that he knows the cause of root-rot, but in the present paper he brings forward only circumstantial evidence to support his opinion. His explanation may seem sufficient to those familiar with the disease in Java only, but it certainly will not carry conviction to those studying root-rot of cane in countries other than Java. He states that the disease is:

> . . . caused by a lack of oxygen, by temporary or constant anaeroby, as for instance in a soil supersaturated with standing water and, therefore, low in oxygen. We mention standing water particularly because the water percentage may be high without being harmful as long as the water itself is in motion and can always supply oxygen, such as sometimes happens very remarkably during floods. This anaerobic root-rot occurs most typically on heavy soils where the drainage is poor; the oversupply of standing water can be caused here by too much irrigation, by floods or by too high a water level. . . . .
>
> But besides this anaerobic root-rot, the disease also occurs on lighter soils where we can hardly speak of anaerobic conditions; we have in mind the soils in Probolinggo, in Kediri, where the structure is such that we have the tendency to speak of good soils and sometimes even of very good soils but here the chances of root-rot are always great. In Wonolangan, Oemboel and Soemberkareng, gravel soils occur which look exceptionally good and yet they are among the most feared soils, especially for E. K. 28. It is mostly the fairly moist soils, soils of the hot-house type, soils which heat quickly. Thus far it has not been possible to characterize these soils sufficiently through bacteriological or chemical analyses to designate them specifically. Reduction generally cannot be shown; we could, therefore, speak of aerobic root-rot. But the two types cannot be kept separate very sharply, they are often mixed and it must be remembered that even in light soils a temporary anaeroby can exist through excess of water which often starts the disease. But based on our experience *in the great majority of root-rot cases an excess of water in the soil is the first cause to think of;* in a great many cases, even on light soils a temporary excess of water could be shown as the detrimental element with a fair degree of certainty. It is quite remarkable that root-rot practically does not occur on the dry lands of Kediri, nor on the so-called dry rice lands, that is on rice fields to which no water is applied during the East monsoon; whereas on ordinary rice lands in the same region, root-rot occurs frequently.
>
> A factor of decided influence upon the occurrence of the disease is a change in the moisture content of the soil; it still remains a question as to whether or not this is a primary factor, but that a plant once affected with root-rot reacts much stronger to the disease in a soil showing marked variation in moisture content than it does in a soil showing but small and gradual changes in this respect may be taken as a fact. This explains why we find less diseased fields in clay soils than we do on lighter soils in the same neighborhood. For instance, it is peculiar that regions with light soils, such as certain parts in Probolinggo, Kediri, and large parts of

*Kuyper, J. Het wortelrot op Java, speciaal in verband met de rietsoort E. K. 28. Mededeelingen van het proefstation voor de Java suikerindustrie. Jaargang, 1923, No. 4.

Djokja and Solo, often have root-rot, whereas regions with much heavier soils in other provinces at practically the same elevation, the disease is much less noticeable. Uniformly moist regions such as Banjoemas, show little root-rot. . . . . . .

This brings us to the phenomenon which we call "dry root-rot." In a great many cases of root-rot, bibit-rot* plays an important part. . . . . . .

In bibit-rot, substances poisonous to the plant develop in the bibit which, under certain conditions, the shoot is forced to absorb. Such circumstances are in general induced by the failure of the roots to furnish a sufficient water supply and this in turn may be caused by the ordinary wet or anaerobic root-rot, but it may also be caused by dry root-rot when the plants, with a poor root system on which falls a heavy duty because of drought, are forced to take the moisture present in the bibit or in the remains of the bibit. Dry root-rot may be considered as bibit-rot but differs from ordinary suffering from drought because the root system is in an unhealthy, insufficient condition. The basic cause of dry root-rot is, therefore, the same as for any other root-rot. . . . . . .

We pointed out before that the main cause of root-rot is an oversupply of water. In each individual case this cannot always be demonstrated with certainty but such has practically been accepted in practice. . . . . . .

However, as stated in the beginning, there is also an aerobic root-rot; a root-rot in connection with which no lack of oxygen or reduction can be demonstrated. The explanation must probably be looked for in another direction.

Dr. Kuyper calls attention to the very evident resemblance of sugar cane root-rot to the "wilt" or "root-rot" of barley in the Netherlands. Experimenters had shown that this barley disease could be controlled in cultures by the addition of manganese sulphate.

A great number of tests with manganese sulphate were carried out in Java in 1921. The Experiment Station supplied the manganese sulphate and fifty-three plantations took the trouble to experiment with it in one or more fields. Only one plantation reported indications of beneficial action and investigations proved that even here the results were, to say the least, doubtful; and we may safely say that $MnSO_4$ has failed as a remedy for root-rot.

Dr. Kuyper states emphatically that no proof has been found either in Java or in any other country that a certain parasite is the cause of the root-rot. He speaks of the disease in Hawaii as follows:

We wish to call attention to the fact that root-rot also occurs in other countries, for instance in Hawaii, where they have looked energetically for vegetable or animal parasities but so far have not succeeded. In the Hawaiian Planters' Record, 23:142, 1920, Carpenter gives an extensive study on the possible connection between Lahaina disease, which corresponds closely with root-rot, and *Pythium*, a well-known fungus. The infection experiments do give indications that this fungus had something to do with the disease but they are far from convincing, Carpenter acknowledges himself to be in a doubtful attitude. . . . .

And finally Carpenter states that a similar fungus is found in diseased roots of other plants such as cannas, colocasia and rice. This seems to indicate again that he is dealing with a widely occurring fungus which acts detrimentally only under definite circumstances.

Root Disease in the West Indies

Root disease appeared in the Bourbon (Lahaina) cane in the West Indies in the early seventies of the last century, and gradually rendered unprofitable the cultivation of this old favorite variety.

Howard[1] was the first plant pathologist to give serious attention to the cane diseases of the West Indies. He held the disease of the Bourbon cane to be the same as the root-disease of the Cheribon in Java and as he found the fungus *Marasmius sacchari* of Wakker to be present, he concluded that it was the cause

*Bibit = seed or cutting.
[1]Howard, A. On Some Diseases of the Sugar Cane in the West Indies. Ann. Bot. 17:373-411, 1903.

of the malady. Since Howard's work appeared, many pathologists have studied the root disease of cane in the West Indies, but, until recent years, they have, without exception, accepted Howard's conclusions and held *Marasmius* to be the cause.

In 1917, Johnston and Stevenson[1] after working on cane diseases in Porto Rico wrote:

> The exact status of root disease with respect to the parasitism of *Marasmius, Himantia, Odontia*, or possible other forms, is uncertain and while it is generally held that *Marasmius* at least is a true parasite, really definite evidence is lacking.

In summing up the work on root disease which had recently been done at the Insular Experiment Station in Porto Rico, under his direction, Earle[2] tells us that "*Marasmius* is at best a very feeble parasite" and "The killing of the roots which is so marked a feature in 'root disease' is usually caused by various species of *Rhizoctonia* and sometimes by a species of *Pythium*."

The most recent opinion on root disease emanating from the West Indies is set forth in a paper by Bourne[3] which has just come to hand. He gives the details of inoculation experiments which he maintains furnish:

> Formal Proof of Pathogenicity of:
> 1. *Rhizoctonia solani* and
> 2. *Rhizoctonia palida.*
>
> There is no doubt that root disease is due to one or the other of the above fungi as determined by the following points:
>
> 1. The constant association of one or the other of the above fungi with the disease and their isolation from typical diseased tissue of the host.
> 2. Healthy sterilized cuttings when inoculated with pure cultures of either of the above fungi in sterilized soil produced plants having characteristic signs of the disease. The penetration of the fungi into the roots has also been observed.
> 3. The fungi have been re-isolated from inoculated diseased roots and when compared in culture with the fungi used for inoculation were identical with them.

Bourne inoculated healthy plants with the two fungi mentioned but, judging from his photographs, he did not obtain anything like as striking results with his *Rhizoctoniae* as Carpenter did with his *Pythium* here in Hawaii in experiments conducted along the same lines.

Root-Rot in Hawaii

Lewton-Brain, coming to Hawaii from Barbados, where he had worked on root disease of the sugar cane, pronounced the malady in Hawaii identical with that in the West Indies; and considered his contention substantiated when he found fructifications of *Marasmius sacchari* in Hawaiian cane fields.

After a brief survey of the situation, Cobb reached the conclusion that *Ithyphallus coralloides* was the most important root-destroying fungus but that *Marasmius* and the so-called "stellate-crystal fungus" also contributed to root disease.

An intensive study of root-rot in the field and laboratory conducted by Larsen and Lyon served to demonstrate that *Ithyphallus* and *Marasmius* had no primary connection with epidemic root-rot in Hawaii and that other fungi were responsible for the destruction of the cane roots. These fungi were taken up in turn but

[1] Johnston, J. R., and Stevenson, J. A. Sugar Cane Fungi and Diseases of Porto Rico. Journal Dept. of Agric. of Porto Rico. 1: 177-251, 1917.

[2] Earle, F. S. Sugar Cane Root Disease. Journal Dept. Agric. of Porto Rico 4:3-27, 1920.

[3] Bourne, B. A. Researches on the Root Disease of Sugar Cane. Dept. of Agric., Barbados. Forwarded to the Government for publication in August, 1922.

each failed to qualify under test as the primary cause of root-rot. Finally by transferring diseased cane stools from diseased to healthy fields, it was demonstrated that these fungi could not materially check the growth of the cane plant if the soil conditions were right. Evidence deduced from extensive field studies and the many experiments performed seemed to prove that the real cause of root-rot in Hawaii was some non-parasitic factor resident in the soil and to indicate that this factor was in the nature of a poison.

The Experiment Station then undertook to determine the nature of this poison and a means of counteracting it. The first clue obtained pointed to black alkali as the toxic ingredient in the soil. This lead was consistently followed until it was definitely proven that we were on the wrong track.

Following the collapse of the black alkali theory, interest in root-rot waned somewhat because seedling canes resistant to root-rot were being rapidly substituted for the susceptible Lahaina with most satisfactory results.

In 1919, root-rot in an aggravated form appeared in the seedling cane H 146. The affected stools were growing in a well-drained, virgin soil and were being irrigated with mountain water. While the appearance and spread of the disease in a seedling cane growing under such conditions did not refute the poison theory, still, it strongly suggested the work of a parasite and we again made a search for an organism of this nature. Examination of living roots revealed the presence of a new chytridiaceous fungus which was evidently responsible for the destruction of the roots in this particular case. This same fungus was found in the roots of diseased Lahaina cane growing under similar conditions and we at once suspected that it might be the universal cause of root-rot which had previously escaped detection because of its minute size and evasive habits. A search foi this organism in other fields where root-rot was most prevalent failed to reveal its presence, however, and we were finally forced to class it with the other parasitic root fungi as virulent only under certain conditions. Of all the fungi credited with ability to attack cane roots this one only is strictly parasitic. It cannot, like all of the others, live on decaying vegetable matter, but feeds only on the living substance of some other plant. In attacking a cane root, it penetrates the growing point and destroys the embryonic tissue located here. In so doing, it effectually stops the growth of the root. Its migration through the soil is so dependent upon special conditions that we might reasonably expect its distribution to be limited rather sharply and this apparently is the case.

Carpenter began working on the root-rot of sugar cane at this time and concluded that the fungus *Pythium* was the cause of the malady. He performed some of the most careful and elaborate cultural and inoculation experiments that have ever been conducted in the study of root-rot of sugar cane; and by the evidence produced he comes nearer proving his contention than has any other pathologist who held a fungus to be the primary cause of the disease.

Carpenter proved that his *Pythium* could act as a parasite attacking the living roots of the cane, and that in so doing, it would seriously retard the growth of a plant. It would not cause the complete collapse of the plants in his experiments, however, even after their vigor was reduced through confinement in pots. More-

over, this *Pythium* is of very general occurrence in the soil throughout the cane fields of Hawaii and not present only where root-rot occurs.

During the latter part of the war, a peculiar disease appeared in the potato fields of Maine. At first, it was thought to be caused by a parasitic organism, but its occurrence was soon correlated with the use of a certain fertilizer. It was found that the trouble was due to borax which accompanied the potash that was being applied in large doses. The potato plant, it seems, is seriously affected by the presence of very small quantities of borax in the soil. As this compound might have been included in fertilizers used in Hawaii, the Experiment Station inaugurated experiments to determine the effect of borax on the cane plant. In tests conducted by the chemists, it was found that cane would tolerate a much higher concentration of this compound in the soil than could possibly have been attained, even though highly contaminated fertilizers had been used. It is evident, therefore, that borax cannot be considered the cause of root-rot in cane in any case.

The Experiment Station is now engaged in determining the possible toxicity to sugar cane of soluble aluminum compounds in the soil. It may quite possibly be that aluminum poisoning is the primary cause of root-rot, for information in hand points strongly in this direction. Investigation along this line was suggested by the work of Hoffer and Carr[1] on the root-rot of corn, an account of which has but recently appeared. These investigators found that corn plants suffering from root-rot always showed peculiar discoloration in certain tissues of their stalks. By experimentation, they found that they could produce similar, if not identical, discoloration by injecting solutions of certain salts of aluminum and iron into normal plants. They then developed methods whereby they could test the tissues of corn plants for the presence of iron and aluminum and found that diseased plants always contained these elements in abnormal quantities. This fact was corroborated in chemical analyses of healthy and diseased plants. They therefore concluded that root-rot in corn was primarily due to the poisoning of the plant through the absorption of toxic quantities of soluble iron and aluminum compounds from the soil. Acting on this hypothesis, they found that applications of lime and phosphates to the soil were very efficacious in preventing or controlling the root-rot of corn. In this connection, they write as follows:

> When lime is added to acid soils it is believed that the conditions which operate to make the aluminum and iron compounds available are destroyed, and even though aluminum salts may still be available after calcium carbonate is added, the addition of soluble phosphates will rapidly precipitate the aluminum salts and render the aluminum inert so far as absorption by corn plants is concerned.

The exact scope of their work and its bearing on our problem may be judged from their own summary, which we quote below:

> (1) One of the most characteristic differences between normally growing corn plants and those which become severely root-rotted is the condition of the vascular plate tissues in the nodes of the stalks. The plants which become severely root-rotted are those which have the nodal tissues discolored and in various stages of disintegration.
>
> (2) This disintegration of the nodal plate tissues begins in the absence of any specific organisms in the tissues.

[1]Hoffer, G. N. and Carr, R. H. Accumulation of Aluminum and Iron Compounds in Corn Plants and Its Probable Relation to Root-rots. Journ. Agric. Research 23: 801-824, 1923.

(3) The brown, yellowish brown, and brownish purple discolorations with their consequent disintegrations which are frequently found in diseased plants have been produced artificially by injecting solutions of certain salts of aluminum and iron into the plants. Definite chlorophyll and leaf-tissue changes have been produced also. Other factors, however, may operate to produce similar effects.

(4) These artificially induced changes in the plant parts closely resemble the phenomena which develop in plants growing in the field under conditions favorable to root-rots.

(5) The most severe cases of root-rots have been found in soils notable because of their deficiencies of lime and available phosphates.

(6) Such soils have variable quantities of salts of aluminum and iron available for absorption by plants.

(7) Corn plants show marked differences in the quantities of aluminum and iron salts which are absorbed by them. These differences develop when the salts are available in subtoxic concentrations in the soil and are believed to be due to specific selective capacities of different plants to absorb the available aluminum and iron salts from the soil. This type of selective absorption cannot operate when the aluminum and iron salts occur in quantities which are toxic to the roots.

(8) A definite cumulative toxicity of aluminum salts within the plants was established by the injection experiments, and it is believed that the same phenomenon occurs naturally in the field. The relative quantities of the available metals and of nitrates in the soil determine, in a large measure, the rate of development of the cumulative toxicity of the metals within the plants. Those plants which contain the largest quantities of these metals are the ones which seem to develop the most severe cases of root-rots when the organisms are present in the soil and the meteorological conditions favor their optimum growth.

(9) When abundant aluminum injuries occur in the corn plants in certain fields it is an indication that the soil is deficient in available phosphates.

(10) The application of lime and phosphates to soils in which root-rots have developed in destructive proportions has been decidedly beneficial in controlling them. The use of limestone alone in some instances proved harmful, but in all cases studied so far the application of available phosphates produced plants which were better and more resistant to the root-rots.

Summary and Conclusions

The final opinion expressed by the Java pathologists is that root-rot is due to the presence, for longer or shorter periods, of stagnant water in the soil. They do not believe that parasitic organisms are in the slightest degree responsible for the malady. The West Indian pathologists, on the other hand, are agreed that parasitic fungi are the primary cause of root-rot and that species of *Rhizoctonia* occupy a place of first importance among these parasites. The conclusion arrived at by Mr. Carpenter here in Hawaii is identical with that held by the cane pathologists of the West Indies except that he would consider *Pythium* rather than *Rhizoctonia* the leading parasite. The writer has proven, to his own satisfaction at least, that parasitic fungi play a secondary part only and that the inception of the disease is due to some non-parasitic factor resident in the soil, this factor most likely being in the nature of a poisonous chemical compound or toxin.

It is a fact recognized by all pathologists that the ultimate destruction of the tissues of the root system is brought about through the action of organisms dwelling in the soil. This is, of course, the fate of all roots that die from any cause whatsoever, so the decay of roots induced by organisms does not, by any means, prove that the death of the roots was due to these organisms. Among the organisms found in cane roots in areas where root-rot is prevalent are several forms with pronounced parasitic abilities. They are capable of attacking, and

do attack, live cane roots, bringing about the destruction of the latter. The only question is: can they, unaided, destroy the roots rapidly enough to produce root-rot in cane? Some pathologists say that they can, while others say that they cannot unless the vitality and resistance of the cane is first reduced or broken down by some non-parasitic factor in the soil. We are, therefore, confronted with two opinions regarding the primary cause of root-rot and we may profitably consider each in turn as correct and see what course should be followed under the circumstances.

If the disease is due primarily and entirely to the attacks of parasitic organisms, the only *cure* is some treatment of the soil that will destroy these parasitic organisms and prevent reinfection without hindering the growth of the cane. This is practically impossible, or, if possible, impracticable. The only salvation of the cane industry under this hypothesis then lies in the use of resistant or immune varieties.

If the disease is due primarily to some non-parasitic factor in the soil, we may be able to correct or eradicate this factor when once we have determined its nature and we shall then be able to grow Lahaina or any other variety of cane indefinitely. If we do not detect and counteract or remove this factor, it may continue to accumulate in the soil until our most tolerant varieties of cane succumb to its influence.

We have arrived at a temporary solution of the root-rot problem by employing resistant or tolerant varieties of cane. If the disease is due to parasitic organisms, we may reasonably expect that these varieties will remain resistant to the malady and our temporary solution will become a permanent solution of the problem. If the disease is due to a non-parasitic factor in the soil, the tolerance of any and all varieties of cane may eventually be exceeded and the entire failure of cane culture follow. During the past two years, well defined cases of root-rot have occurred in Yellow Caledonia, Yellow Tip, D 1135 and H 109. These are the resistant varieties which saved the industry when Lahaina failed because of root-rot.

If we accept the conclusion that root-rot is due entirely to parasitic organisms, we have all the necessary data at our command and can at once define the only logical course to follow. We can profitably abandon further search for parasitic root fungi, for there can be no possible doubt but that all of those associated with root-rot have been detected. There is no parasitic organism yet to be discovered, for it is easily demonstrated that the known organisms are the ones actually responsible for the decay of the roots. The question as to which fungus leads in the attack is of no practical importance. Treatment aimed at any one of them will be equally efficacious against all, but, since soil treatments offer no permanent relief from these fungi, the only means of defeating them is through the employment of resistant or immune varieties of cane.

If, on the other hand, we tolerate a suspicion that root-rot is induced primarily by some deleterious compound or toxin accumulating in the soil, we should make a desperate effort to detect this agent and to devise a means of rendering it harmless.

Adco Manures

Rothamsted Experimental Station

Mr. E. Hannaford Richards, who is experimenting with various materials in the so-called manufacture of artificial manure, has made tests with sugar cane trash and bagasse. He furnishes Mr. F. Muir the following data concerning these manures, which bear the trade name of ADCO. He makes the following comments:

No doubt your trash and bagasse will have very much the same composition as that from Mauritius. The analyses of trash and bagasse after fermentation are given on the sheet attached. Trash will make a better manure than bagasse. The latter is too woody and I do not regard it as a very promising material, especially as it is used as fuel, but any surplus might possibly be worked up with trash. The fine powder mentioned in the last paragraph of your letter can certainly be used in this way.

At present our information is limited to the fermentation of small samples of trash and bagasse in the laboratory. Until tests have been made on a practical scale it is very difficult to say how the manure will compare with your present method of supplying nitrogen to the soil from the economic standpoint. Assuming that trash will rot down on the large scale as it does in the laboratory, it is probable that the nitrogen applied in this form will give a larger return spread over several crops than is obtained from sulphate of ammonia applied direct to the soil. I quite realize that the conditions of the sugar industry in Hawaii may upset this conclusion, which is based on long experience of farm trials in England.

The obvious course is to get a trial carried out, and only then will it be possible to say whether the ADCO Process offers any decisive advantage over the older methods.

X

ANALYSES OF ADCO MANURES

Material Treated	Moisture	Nirtogen as Ammonia	Total Nitrogen	Phosphate	Potash	Loss on Ignition (Organic)	Ash
Bagasse	87.50	0.05	0.19	0.02	0.06	12.06	0.44
Trash	88.15	0.05	0.23	0.02	0.11	9.54	1.96
Wheat Straw......	76.00	0.07	0.52	0.13	0.14	18.86	5.14
Cow Dung (for comparison)	80.56	0.09	0.43	0.19	0.44	15.27	4.17

H. P. A.

Observations on Varieties on the Plantations

By J. S. B. Pratt, Jr.

During the past few months the writer has had the opportunity of observing seedlings and the old standard varieties on all the plantations. The following comments as to their behavior will be of interest to those places having these canes.

The largest change in varieties outside of the spread of H 109 is the extent to which D 1135 has increased, particularly on the island of Hawaii. Honokaa's area is practically all D 1135, and the plantations from there into Hilo are extending it as fast as they can get seed. It is rapidly replacing Yellow Caledonia as a middle belt and mauka land cane. Kau district is also extending it, and fields may be seen with very heavy cane with sticks large in diameter. It is able to withstand the severe conditions of the Hamakua district, and the old prejudice against it on account of harvesting costs is being lost with the increase in yields and the resultant decrease of cultivation costs. An experiment at Pioneer Mill, harvested this year, showed the superiority of this cane at the 600 ft. elevation under dry conditions. Oahu Sugar Company has an excellent field at about the same elevation near Kipapa Gulch. On the other hand, it has been dropped from Ewa completely, not competing with H 109 on the lower levels.

Yellow Caledonia on Kauai is being rapidly replaced by H 109 on the lower fields and with Yellow Tip on the upper fields. It is of the utmost importance that a cane be found that will take the place of Yellow Caledonia in the Hilo district should anything happen to that variety, as has happened to it on Kauai.

Yellow Tip is increasing in area as a mauka land cane but should be looked upon as a temporary substitute. Some variety more resistant to yellow stripe disease should be found.

Striped Mexican continues to be Wailuku's early cane, giving excellent juice there. It is on trial in a 50-acre field at Hawi. Pioneer finds it a very satisfactory cane for its conditions. However, a small plot looks very poorly at Grove Farm. Waianae is trying it. It became badly affected by Lahaina disease when tried at Ewa a number of years ago.

D 117 is rapidly losing favor on account of its falling down in yields on the ratoons.

Rose Bamboo, Yellow Bamboo, and H 146 have decreased areas.

Badila has found favor at Kilauea, Makee, Knudsen, Hakalau and Kohala. This cane requires moist conditions for optimum growth, and observations indicate that it does the best where we have the wet black soil, which is found in parts of the islands. Any cane needs good drainage, however.

Of the original H seedlings, only one has been developed to any extent. H 109 has increased until it now has 24 per cent of the Islands' cane acreage. It has become adapted to a wide range of conditions, but it has not found favor on Hawaii, where the colder, wet conditions make it a very expensive cane to raise. Hawi plantation will decrease its area, H 109 ratooning very poorly for them.

H146 for a time was being extended, but its ratoons did not come up to expectations, with the result that its area has been decreased rapidly. Waialua still reports excellent yields from it. H 146 is somewhat subject to Lahaina disease or at least some form of root-rot. As possibly four-fifths of our crop is in ratoons, our new seedlings must be able to give us good yields on the ratoons.

H 389 is being extended somewhat on the upper levels of Hilo Sugar Company. It is a cane much resembling D 1135, with larger sticks. On this plantation, as on many others, H 227 has a poor stand and will not be extended.

H 349 is found in a few acres at Ookala, and at Paauilo. The drawback to this cane is that it does not stool very heavily, but it does have very long sticks, giving enough tonnage to keep the variety.

Of the so-called H 400 varieties, H 456, H 472, H 468 and H 471 are the best. The objection to H 456 on several plantations that the variety does not ratoon does not seem to hold at Onomea, where it is doing exceptionally well. It is a cane with a broad leaf, a type desired in the Hilo district, and in the test at Onomea had an excellent quality of juice, as well as yield in cane. An abundance of moisture may be the factor required to make it a good ratooner. At the 1800 ft. elevation at Olaa, the acreage is being extended.

H 456 and H 472 both yielded better than Yellow Caledonia in a very exhaustive test with the 400 varieties at Grove Farm. Appearances indicate that these canes may have to be harvested early. H 472 we find well liked at Onomea, Koloa and Grove Farm.

H 463 was excellent at Hakalau and Grove Farm, but at the latter place recently showed that it has a weak resistance to invasions of fungi through the rind.

H 468, a Striped Mexican seedling, withstands the dry conditions of Waimanalo.

H 471 is a good cane on the upper lands of Onomea.

H 5001 looked promising for a time, but its inability to ratoon places it in the background.

The H 5900s have been tried out on all the Islands, with H 5965, H 5972, H 5909, H 5919, H 5922 and H 5923 the best. H 5927 was very badly affected by eye-spot at Pahala, and should be watched for this weakness. Perhaps the best of these 5900s is H 5965. We have noted its adaptability to Pahala, Honokaa and Waialua conditions. It was very good also at Hawi. H 5972 grows well under Kilauea and Pahala conditions, is a large cane with a big eye, but was affected by eye-spot badly at Waialua. Mr. E. E. Naquin, of Honokaa, reports that it also becomes badly affected by mosaic disease.

H 5919 ranked well with H 109 in a recent test at Ewa.

Some of the H 8900 seedlings look as promising as their parent, H 109. These have been tested on first ratoons at Waimanalo, Hawi, Waipio and Oahu Sugar Company. During the past few months they were well distributed on Kauai, Maui, and Oahu. The ones of most promise to date are H 8961, H 8973, H 8978, H 8965, H 8977, H 8973, H 8988, H 8948, H 8958, H 8994 and H 89102. This lot shows very great promise. The first four were better than H 109 at Waimanalo on first ratoons.

H 8949 is very badly affected by eyespot at Makiki.

H 5803 is a seedling of D 117, with many D 1135 characteristics. At our Manoa substation, at Koloa, Grove Farm, Ookala and Honokaa, we note that it is a cane that is worth watching. It has D 1135's character of being a good ratooner.

H 1801 was one of some promise at Manoa. It has not come up to expectations at Grove Farm, Koloa, Kaiwiki, Mr. Chas. Rice's or Honokaa. It gives a large number of germinations in the seedling nursery.

The Wailuku seedlings are proving adaptable to varied conditions. Wailuku already has ten to fifteen acres of some of these. It is interesting to note that some of the best ones at Wailuku were found to be worth extending at Koloa. These are W 2, 5, 9, 10 and 4. W 1 is a fast growing cane, but must be watched for mosaic disease. These seedlings are now on several places on Kauai, at Ewa, a few at Kahuku, at Puunene and Waipio.

Wailuku 2, when cut at eleven months had excellent juice and 55 tons cane per acre at Onomea. Here the ratoons have a good stand.

Of the many seedlings raised at Ewa, some twenty-five are being watched with interest. These are Ewa Nos. 177, 199, 225, 325, 362, 378, 380, 386, 387, 405, 421, 509, 555, 570, 700, 710, 712, 720, 731, 732, 737, 740, 759 and 569.

Hawaiian Sugar Company has raised a large number of seedlings. This plantation has numbered four of considerable promise of the 1918 propagation, Makaweli Nos. 1, 2, 3 and 4.

Honokaa No. 1 (OP 229-1917), a Striped Mexican seedling, is grown at Honokaa to the extent of fourteen acres, at all elevations. It resembles D 1135 in character of growth. The same cane has been extended by Olaa to several acres, but on the lower fields at Pioneer it looks very poorly. This is a strong example of the necessity of trying a cane out under all plantation conditions before it is discarded, and proves the contention that it is really on the plantations that the canes have to be developed.

Kohala Sugar Company has developed several canes that will be worth trying out on the mauka lands of Hawaii and Kauai. Kohala Sugar Company has ten to fifteen acres of some of these, and the following numbers are the most promising on the second ratoons: K 107, K 117, K 202, K 73, K 86, K 36, K 382, K 115, K 20 and K 101. These are largely D 1135 seedlings that have been crossed with Striped or Yellow Tip, and have many of the Tip characters that are desirable as cheap canes for mauka lands. At Onomea, we note that K 73 and K 86 are ratooning excellently at the 1000 ft. elevation, the former having the preference. Honokaa reports that 220 is the ranking Kohala seedling for their conditions. Seed of several of these Kohala seedlings is being raised at Manoa substation for distribution to plantations this coming spring. They are of the type desirable for mauka land canes, but their resistance to disease is not known.

Kohala No. 4 is making a fine start at Ewa and we are interested in seeing how this seedling makes out under warm, ideal conditions. It is not the type desired in the Kohala district.

As future mauka land seedlings, Mr. Jennings has put into the field this year some twenty-three thousand seedlings, largely of Tip and D 1135 crosses.

Several Badila seedlings are being tried out on Kauai and Hawaii. H 9811 is the best at Honokaa, and among the better ones at Kilauea. It is interesting to note that it is by far the best ratooner at Manoa on the second ratoons, and at Makiki plots it had a very heavy growth, with long joints. H 9804, H 9812 and H 9809 are among the better Badila seedlings.

The 1917 Oahu propagation seedlings were sent out to several plantations without having H numbers assigned. Pioneer Mill Company is carrying on some thirty of these. Ewa recently harvested these canes with 394-1917, an H 109 seedling, and 347-1917, a Lahaina seedling, comparing very favorably with H 109. No. 229-1917 is now Honokaa No. 1, and is also doing well at Olaa. Olaa is watching several of this lot, and Kilauea has a few of interest, but no harvesting data on their behavior has been obtained as yet.

Bud Selection

A Preliminary Report on Results and Methods

By J. A. Verret

Mr. Shamel is to write a report on the progress of the bud selection work for 1923. It is planned to have this report contain full details of the work being done, of the methods being recommended for use in this work, etc. As some of the material to be used will not be available for several months it will be late in the year before the report is out.

Progeny 1.

Progeny 2.

On this account we thought it might be of some advantage if we published at this time a short, preliminary outline of the 1923 developments in bud selection work. It occurred to us that the simplest way to do this would be to briefly describe some of the work actually done.

For this purpose we have selected a small progeny test consisting of five progenies, here at Makiki Plots.

General

In harvesting this area the weighing method adopted this year was used. Each stool was weighed separately, the number of stalks counted, and the length of row measured. From these data the average number of stalks per foot, the weight of cane per foot of row, the weight per stalk, the weight per stool and the estimated tons per acre were calculated.

These progenies originally consisted of one stool each from seed selected by W. W. G. Moir on Maui.

The following descriptions of these canes are from Mr. Moir's notes made at the time of selecting:

No. 1. Oval-stalked, semi-erect, large-eyed, strong white.
No. 2. Semi-erect, slender-stalked, small-eyed, orange.
No. 3. Erect, white, strong growth, medium to large stalk, medium eye.
No. 4. Semi-erect to erect, small-winged eye.
No. 5. Semi-erect to recumbent.

Type No. 1 was secured from some left over stalks that were to be exhibited at the Maui County Fair two years ago by Wailuku Sugar Company. I picked up the stalk from among several of type No. 4 and No. 5. Later I found out that the particular stalk came from a large prize stool (20 stalks) dug up at Waikapu, but which broke up before it was removed to the truck to be transported to the Fair grounds.

Progeny 3.

Progeny 4.

Type No. 2 was a stool of 12 stalks sent in by Waihee section of Wailuku Sugar Company for entry in the competition for the best Selected Stool but it was not entered because the stools from Waikapu were better. The stool was uniform, consistent throughout in regard to type, but for general desirability of type and excellence of growth it was poor.

Type No. 3 was a stool of 12 stalks growing in field G, Puunene, at the end of a level ditch. It would have taken a very high total of points if entered in the "Best Stool of Cane for Selection Purposes" class, but still would not have taken a first prize because of its slower growth and poorer total tonnage.

Type No. 4 }
Type No. 5 } Standard H 109 types secured in H 109 field (Field G Puunene). Under similar environments these two are practically identical but No. 4 would appear to have more vigor.

The stools showed differences in growth from the first. At the age of one year enough seed was selected to plant 50 running feet of each. This seed was planted in 5 rows, each 50 feet long. Ten feet of each progeny was planted in each row, giving five repetitions for each. The method of planting is illustrated below:

Row 1	Row 2	Row 3	Row 4	Row 5
Prog. 5—Plot 21	Prog. 4—Plot 16	Prog. 3—Plot 11	Prog. 2—Plot 6	Prog. 1—Plot 1
" 1— " 22	" 5— " 17	" 4— " 12	" 3— " 7	" 2— " 2
" 2— " 23	" 1— " 18	" 5— " 13	" 4— " 8	" 3— " 3
" 3— " 24	" 2— " 19	" 1— " 14	" 5— " 9	" 4— " 4
" 4— " 25	" 3— " 20	" 2— " 15	" 1— " 10	" 5— " 5

The average results are summarized as follows:

Progeny No.	No. of stools	No. of stalks	Total Weight	Av. stalks per ft.	Wgt. per ft.	Wgt. per stalk	Wgt. per stool	Tons per acre	Stalks per stool
1	40	207	648	4.14	13.0	3.00	16.2	56.5	5.14
2	31	157	420	3.14	8.4	2.62	13.5	36.5	5.06
3	35	189	539	3.78	10.8	2.86	15.7	47.0	5.40
4	39	168	507	3.36	10.1	2.98	13.0	44.1	4.31
5	36	177	538	3.54	10.8	3.02	15.6	46.8	4.89
Total av.	181	898	2652	3.59	10.6	2.95	14.6	46.2	4.96

From the above general summary we see that progeny 1 is distinctly better than any other. The weight of cane per foot is greater, it has more stalks per foot and the stalks weigh more. Of the other progenies, 3 and 5 are about equal, while Progeny 2 is very much inferior.

In Fig. 1 we have attempted to show these differences in a graphic way. Progeny 1 was planted in plots 1, 10, 14, 18 and 22. If we compare the yields from these plots we find that they are always greater than the yields from any adjoining plot. That is, plot 1 produced more cane than either 2 or 6, plot 10 was better than either 5, 9 or 15; plot 14 was better than 9, 13, 15 or 19, and so on.

Results of this nature prove conclusively that in this case progeny 1 is superior to any other in this lot. It now remains to prove whether this superior progeny will continue being superior or will it go back.

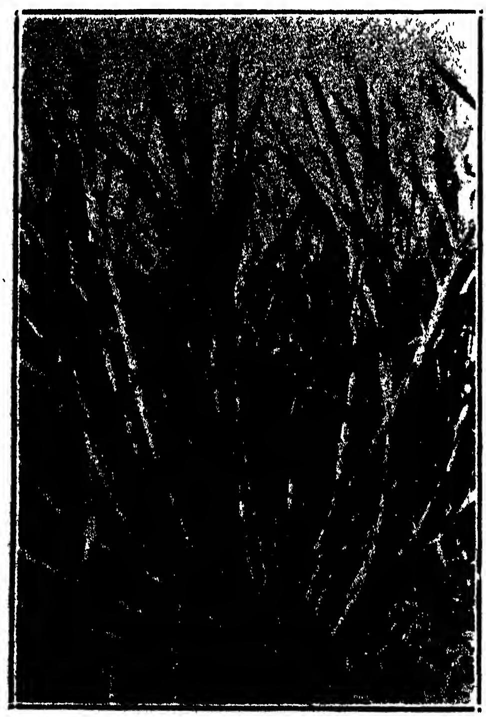
The results in regard to the poor Progeny, No. 2, are almost as conclusive. Progeny 2 was in plots 2, 6, 15, 19 and 23. The yields from progeny 2 are always less than that of any of the adjoining plots except in two cases. Plot 24 is poorer than 23, and plot 11 is poorer than 6; in all other cases Progeny 2 was poorer.

If we were doing this work on a plantation we would select progeny 1 for further work. All the others would be discarded, except that we would plant some few seed of Progeny 2 in our progeny areas for purposes of comparison to see if this progeny remains poor, improves or possibly goes back entirely.

In this case we are keeping one progeny out of five on the second selection. We believe this to be a fair figure. Twenty to thirty per cent seems to be about how it works out.

All the good seed from Progeny 1 should be planted. Seed from the best stools for further progeny work and the other seed should be planted by itself for plantation seed later, because, if Progeny 1 remains good, this will furnish seed superior to the general run of plantation seed and at no extra cost.

Progenies 3 and 5 are as good or better than plantation run, so all good seed from these could be used for plantation planting. In no case should seed from Progeny 2 be used for plantation planting as that would be spreading what is evidently a very inferior strain.



Progeny 5

In selecting stools from Progeny 1 for progeny planting we proceed as follows: We note that the average weight per stool was 16.2 pounds and the average weight per stalk 3.00 pounds, and that there were 5.14 stalks per stool. Stools which are to be selected for progeny planting should equal or surpass this average. This standard may be varied to suit conditions, such as size of area available for progeny planting. We do not believe this selection within the progeny to be nearly so important as the selection of the progeny itself, and the total discarding of the poor ones. No matter how high the stool standard is set within each progeny there

is no loss as all the remaining seed (of the good progenies) goes for plantation or mother field planting.

In the detailed data given at the end of this article we indicate the stools which were selected and planted. In some cases you will note we lowered the standard in weight of stalk or number of stalks per stool when some other item was very high. Stool 1-10 consisted of four stalks only, but the stalks weighed 4.8 pounds each, so that stool was taken. Stool 1-18 had stalks weighing only 2.69 pounds each but this stool had 9 stalks with a total weight of 24¼ pounds. In selecting, the primary factor to consider, of course, is the comparative weight of cane per foot of row, the other factors being of secondary importance and should be regarded as such.

In progeny planting, when several stools are selected, the seed of each is planted together and separated from the seed of the next stool by means of a stake or by planting one or two seeds of another variety of cane.

In our progeny planting at Waipio and at Makiki we use so-called Cuban-seed, that is, a 3-eye cutting from which the two end eyes are gouged out. At Waipio we plant one eye per running foot. In Honolulu, where we expect to make a closer stool study, we space the eyes two feet apart. In every line we plant two or three extra eyes in order to have material of the same kind to replant any misses. After germination is completed, any of these extra seed not used for replanting are dug up and discarded.

After trying a number of systems we have concluded that numbering the progenies should be made as simple as possible. A method which we favor is as follows: In the first stool selection, the selected stools are to be given temporary numbers, and called stool 1, stool 2, etc. They are not to be given progeny numbers until after the first selection. If a plantation selects 1,000 stools they are numbered 1 to 1,000. Then, if at the first selection 200 of these stools are kept for further study, these selected stools are given progeny numbers 1 to 200, or if the plantation already has progenies, the new ones are numbered consecutively from the last numbered progeny. Proper notes are made in the records to show from which stool the progeny originated. From then on no changes are made in the progeny numbers.

At the next selection, if stool selections are made within the progeny and planted as units the stool number is added to the progeny number. If the first stool in Progeny 10 is selected it is numbered 10-1, the fifth stool would be 10-5, etc. All "mass" plantings of Progeny 10 would continue to be known simply as Progeny 10. In the fourth selection if 10-1 is taken and again separated into stool planting we add the stool number as before; if the second and sixth stools are taken the numbers would be 10-1-2, and 10-1-6. All mass planting would again be simply Progeny 10.

We have discontinued the "snake fashion" planting as we find that it offers certain inconveniences when the weighing method is used. In irrigated fields we plant full lines of each progeny. In case there is not enough seed we finish the line with another variety and start the next progeny on a new line.

Progeny Planting at Makiki Plots

We shall now briefly describe our handling of the above five Makiki progenies for further study.

Progeny 1 was selected as the best.

We selected what we considered the 18 best stools. These were numbered 1-1 to 1-18. Progeny 3 was very uniform and possibly the next best. We selected the 10 best stools from this.

Progeny 2 was markedly the poorest progeny, so we determined to carry this along as a poor progeny for purposes of comparison. In order to illustrate, if possible, the effect of selection downward as well as upward, we selected for planting only the poorest stools in Progeny 2. So we now have for comparison the best stools and seed from the best progenies and the poorest stools and seed from the poorest progeny.

In all cases we used a 3-eye seed piece with two eyes cut out, and spaced the eyes 2 feet in a 30-foot line. In each line we planted 3 extra eyes from the same stool if possible, in order to be able to replant any misses.

The plan of the planting is given below:

Test 3. Section 2. Seed from Section 11, Test 2. Planted June, 1923.

Row	Makiki Progeny.			
1	3-10	(15)	3 extra	
2	1-18	(15)	2 "	
3	3-9	(14)	4 "	from stool 3-10
4	1-17	(15)	3 "	
5	3-8	(15)	2 "	
6	1-16	(15)	2 "	
7	2-12	(15)	3 "	
8	1-15	(15)	1 "	
9	3-7	(15)	2 "	
10	1-14	(15)	1 "	
11	2-10	(6)		2-11 (6) 3 extra not from same stool
12	1-13	(15)	3 "	
13	3-6	(15)	3 "	
14	1-12	(15)	3 "	
15	2-9	(13)	6 "	not from same stool
16	1-11	(15)	3 "	
17	3-5	(15)	3 "	
18	1-10	(15)	3 "	from stool 1-11
19	2-7	(10)		2-8 (5) 3 extra
20	1-9	(15)	3 "	
21	3-4	(12)	6 "	not from same stool
22	1-8	(15)	3 "	
23	2-5	(10)		2-6 (5) 3 extra
24	1-7	(15)	3 "	
25	3-3	(15)	3 "	
26	1-6	(15)	3 "	
27	2-3	(8)	2 "	2-4 (3) 5 extra not from same stool.
28	1-5	(15)	3 "	
29	3-2	(15)	3 "	
30	1-4	(15)	2 "	
31	2-2	(15)	3 "	
32	1-3	(15)	1 "	
33	3-1	(15)	3 "	
34	1-2	(15)	3 "	
35	2-1	(15)	3 "	
36	1-1	(15)	3 "	
	crop			

In the above outline the figure 1-1 in line 1 indicates the first stool in Progeny 1. This is the legend placed on the stake. The other figures are not to be on the

stake, but on the map only. The (15) shows 15 eyes spaced 2 feet apart in the 30-foot row. Three extra seeds from this same stool were planted for replacement in case some of the 15 should not come up. As soon as germination is complete all "extras" not needed are to be dug up. In this way we are to have no misses, and the replacements are to be from the same material. In some cases, as in line 11, there was not enough seed from 1 stool to plant a line, in which case 2 stools were used.

We would suggest that small tests of this nature be laid out on the plantations which are doing seed selection work. A small area only is needed. In the above layout we used 36 lines 30 feet long.

By such a procedure we would soon have very valuable information as to actual value of bud selection work. Such tests would be extremely interesting to all in indicating the extremes possible. The good progenies would indicate the possible gains to be expected and the poor progenies would show what is likely to happen when such material is planted.

10 ft. Row No..	Row No........	Progeny No.....	Stool No........	No. of Stalks...	Wgt. per Stool..	Aver. Stalks per Foot.....	Wgt. per Foot...	Wgt. per Stalk..	Wgt. per Stool..	Tons per Acre...	Remarks
1	36	4	1	4	11.2	..	....	2.4	...	...	
..	..	..	2	5	7.8	..	....	1.6	...	...	
..	..	..	3	4	11.5	..	....	2.9	...	...	
..	..	..	4	2	10.7	..	....	5.3	...	...	
..	..	..	5	3	14.9	..	....	5.0	...	...	
..	..	..	6	7	15.1	..	....	2.2	...	...	
..	..	..	7	4	11.4	..	....	2.9	...	...	
..	..	..	8	6	19.4	..	....	3.2	...	...	
Average				35	102.0	3.5	10.2	2.9	12.8	44.4	
1	37	3	1	8	26.7	..	....	3.3	...	...	3–2 Planted
..	..	..	2	4	11.6	..	....	2.9	...	...	
..	..	..	3	3	6.2	..	....	2.1	...	...	
..	..	..	4	4	15.1	..	....	3.8	...	...	
..	..	..	5	5	11.1	..	....	2.2	...	...	
..	..	..	6	6	17.2	..	....	2.9	...	...	
..	..	..	7	13	28.4	..	....	2.2	...	...	3–1 Planted
Average				43	116.1	4.3	11.6	2.7	18.0	50.5	
1	38	2	1	6	18.6	..	....	3.1	...	...	
..	..	..	2	4	13.2	..	....	3.3	...	...	
..	..	..	3	7	20.1	..	....	2.3	...	...	
..	..	..	4	5	15.0	..	....	3.0	...	...	
..	..	..	5	6	13.2	..	....	2.2	...	...	
..	..	..	6	13	40.9	..	....	3.1	...	...	
Average				41	121.0	4.1	12.1	3.0	20.3	52.7	
1	40	5	1	10	31.5	..	....	3.2	...	...	
..	..	..	2	5	14.9	..	....	2.4	...	...	
..	..	..	3	7	32.7	..	....	4.7	...	...	
..	..	..	4	5	15.3	..	....	3.1	...	...	
..	..	..	5	7	25.5	..	....	3.6	...	...	
..	..	..	6	10	32.6	..	....	3.3	...	...	
..	..	..	7	4	3.2	..	....	.8	...	...	
Average				48	155.7	4.8	15.6	3.2	22.2	67.5	

10 ft. Row No..	Row No........	Progeny No.....	Stool No........	No. of Stalks...	Wgt. per Stool..	Aver. Stalks per Foot.....	Wgt. per Foot..	Wgt. per Stalk..	Wgt. per Stool..	Tons per Acre..	Remarks
1	39	1	1	6	21.2	..	....	3.5	...	...	1–6 Planted
..	..	..	2	8	26.4	..	....	3.3	...	...	1–5 Planted
..	..	..	3	4	16.5	..	....	4.1	...	...	1–4 Planted
..	..	..	4	4	11.6	..	....	2.9	...	...	
..	..	..	5	6	26.5	..	....	4.4	...	...	1–3 Planted
..	..	..	6	7	20.9	..	....	3.0	...	...	1–2 Planted
..	..	..	7	7	29.1	..	....	4.2	...	...	1–1 Planted
..	..	..	8	7	20.6	..	....	2.9	...	...	
Average				49	172.8	4.9	17.3	3.5	21.6	75.3	
2	36	3	1	2	1.4	..	....	0.7	...	...	
..	..	..	2	3	5.5	..	....	1.8	...	...	
..	..	..	3	4	15.9	..	....	4.0	...	...	
..	..	..	4	5	17.1	..	....	3.4	...	...	3–4 Planted
..	..	..	5	7	23.2	..	....	3.3	...	...	3–3 Planted
..	..	..	6	4	15.5	..	....	3.9	...	...	
..	..	..	7	5	12.1	..	....	2.4	...	...	
Average				30	90.7	3.0	9.1	3.0	12.9	42.3	
2	37	2	1	1	.4	...	....	.4	...	...	2–4 Planted
..	..	..	2	5	10.9	..	....	2.2	...	...	2–3 Planted
..	..	..	3	6	18.9	..	....	3.2	...	...	2–2 Planted
..	..	..	4	5	11.0	..	....	2.2	...	...	2–1 Planted
Average				17	41.2	1.7	4.12	2.4	10.3	17.8	

10 ft. Row No..	Row No........	Progeny No.....	Stool No........	No. of Stalks...	Wgt. per Stool..	Aver. Stalks per Foot.....	Wgt. per Foot...	Wgt. per Stalk..	Wgt. per Stool..	Tons per Acre...	Remarks
2	38	1	1	5	18.0	..	....	3.6	...	...	1–12 Planted
..	..	..	2	6	21.4	..	....	3.6	...	....	1–11 Planted
..	..	..	3	4	19.2	..	....	4.8	...	...	1–10 Planted
..	..	..	4	6	22.0	..	....	3.7	...	...	1–9 Planted
..	..	..	5	5	18.5	..	....	3.7	...	...	1–8 Planted
..	..	..	6	7	22.0	..	....	3.1	...	...	1–7 Planted
..	..	..	7	3	5.0	..	....	1.7	...	...	
..	..	..	8	3	10.4	..	....	3.5	...	...	
Average				39	136.5	3.9	13.65	3.2	17.1	59.5	
2	39	5	1	5	15.8	...	....	3.2	...	...	
..	..	..	2	5	16.1	..	....	3.2	...	...	
..	..	..	3	6	13.9	..	....	2.3	...	...	
..	..	..	4	6	18.9	..	....	3.1	...	...	
..	..	..	5	5	14.7	..	....	2.9	...	...	
..	..	..	6	3	11.0	..	....	3.7	...	...	
..	..	..	7	5	17.0	..	....	3.4	...	...	
Average				35	107.4	3.5	10.74	3.07	15.3	46.8	
2	40	4	1	6	18.4	..	....	3.1	...	...	
..	..	..	2	5	13.6	..	....	2.7	...	...	
..	..	..	3	5	16.0	..	....	3.2	...	...	
..	..	..	4	6	16.0	..	....	2.7	...	...	
..	..	..	5	7	25.7	..	....	3.7	...	...	
..	..	..	6	4	15.8	..	....	3.9	...	...	
..	..	..	7	3	10.3	..	....	3.4	...	...	
..	..	..	8	4	17.2	..	....	4.3	...	...	
Average				39	133.0	3.9	13.3	3.41	16.6	57.9	

10 ft. Row No..	Row No........	Progeny No.....	Stool No.......	No. of Stalks...	Wgt. per Stool..	Aver. Stalks per Foot.....	Wgt. per Foot..	Wgt. per Stalk..	Wgt. per Stool..	Tons per Acre..	Remarks
3	36	2	1	4	6.0	..	....	1.5	...	...	2–5 Planted
..	..	..	2	4	6.5	..	....	1.62	...	...	2–6 Planted
..	..	..	3	3	9.5	..	....	3.19	...	...	
..	..	..	4	4	13.25	..	....	3.31	...	...	
..	..	..	5	5	16.0	..	....	3.20	...	...	
..	..	..	6	7	14.25	..	....	2.03	...	...	
Average			4.5	27	65.5	2.7	65.5	2.43	10.9	28.3	
3	37	1	1	7	20.75	..	....	2.96	...	...	1–17 Planted
..	..	..	2	4	9.75	..	....	2.44	...	...	
..	..	..	3	2	4.25	..	....	2.12	...	...	
..	..	..	4	4	9.75	..	....	2.44	...	...	
..	..	..	5	5	18.5	..	....	3.70	...	...	1–16 Planted
..	..	..	6	5	19.8	..	....	3.96	...	...	1–15 Planted
..	..	..	7	4	18.0	..	....	4.50	...	...	1–14 Planted
..	..	..	8	8	28.25	..	....	3.53	...	...	1–13 Planted
Average			4.86	39	129.1	3.9	12.9	3.05	16.1	56.2	
3	38	5	1	6	18.25	..	....	3.04	...	...	
..	..	..	2	8	17.00	..	....	2.13	...	...	
..	..	..	3	5	18.00	..	....	3.60	...	...	
..	..	..	4	5	10.75	..	....	2.05	...	...	
..	..	..	5	3	6.75	..	....	2.25	...	...	
..	..	..	6	8	24.00	..	....	3.00	...	...	
..	..	..	7	6	23.75	..	....	3.96	...	...	
Average			5.87	41	118.0	4.1	11.8	2.88	19.7	51.4	

10 ft. Row No..	Row No........	Progeny No.....	Stool No.......	No. of Stalks...	Wgt. per Stool..	Aver. Stalks per Foot.....	Wgt. per Foot...	Wgt. per Stalk..	Wgt. per Stool..	Tons per Acre...	Remarks
3	40	3	1	8	20.0	..	....	2.50	...	...	
..	..	..	2	5	15.75	..	....	3.15	...	...	
..	..	..	3	2	5.5	..	....	2.75	...	..	
..	..	..	4	4	11.8	..	....	2.95	...	...	
..	..	..	5	7	19.75	..	....	2.82	...	...	3–6 Planted
..	..	..	6	8	22.0	..	....	2.75	...	...	3–5 Planted
..	..	..	7	5	11.0	..	....	2.20	...	...	
Average			5.57	39	105.8	3.9	10.58	2.72	15.1	46.0	
3	39	4	1	3	6.75	..	....	2.25	...	...	
..	..	..	2	5	14.25	..	....	2.85	...	...	
..	..	..	3	4	16.50	..	....	4.12	...	...	
..	..	..	4	5	17.00	..	....	3.40	...	...	
..	..	..	5	6	17.50	..	....	2.92	...	...	
..	..	..	6	5	17.00	..	....	3.40	...	...	
..	..	..	7	4	12.25	..	....	3.06	...	...	
..	..	..	8	4	14.00	..	....	3.50	...	...	
Average			4.5	36	115.25	3.6	11.5	3.20	14.40	50.1	

SUMMARY

Row No.	Progeny No.	No. of Stools	No. of Stalks	Total Weight	Aver. Stalks per Foot	Wgt. per Foot	Wgt. per Stalk	Wgt. per Stool	Tons per Acre	Remarks
39	1	8	49	172.8	4.9	17.30	3.50	21.6	75.3	
38	1	8	39	136.5	3.9	13.60	3.20	17.1	59.5	
37	1	8	39	129.1	3.9	12.90	3.05	16.1	56.2	
36	1	8	32	84.6	3.2	8.46	2.64	10.6	36.8	
40	1	8	48	125.1	4.8	12.51	2.61	15.7	54.5	
Average		40	207	648.1	4.14	12.95	3.00	16.20	56.5	
38	2	6	41	121.6	4.1	12.10	3.00	20.3	52.7	
37	2	4	17	41.2	1.7	4.12	2.40	10.3	17.8	
36	2	6	27	65.5	2.7	6.55	2.43	10.9	28.3	
40	2	7	38	118.9	3.8	11.89	3.13	17.0	51.8	
39	2	8	34	72.8	3.4	7.28	2.14	9.1	31.8	
Average		31	157	420.0	3.14	8.39	2.62	13.5	36.5	
37	3	7	43	116.1	4.3	11.60	2.70	18.0	50.5	
36	3	7	30	90.7	3.0	9.10	3.00	12.9	42.3	
40	3	7	39	105.8	3.9	10.58	2.72	15.1	46.0	
39	3	7	39	122.9	3.9	12.29	3.15	17.6	53.5	
38	3	7	38	103.3	3.8	10.83	2.73	14.7	42.8	
Average		35	189	538.8	3.78	10.78	2.86	15.71	47.0	
36	4	8	35	102.0	3.5	10.2	2.90	12.8	44.4	
40	4	8	39	133.0	3.9	13.3	3.41	16.6	57.9	
39	4	8	36	115.3	3.6	11.5	3.20	14.4	50.1	
38	4	7	32	91.1	3.2	9.1	2.84	13.0	39.6	
37	4	8	26	66.0	2.6	6.6	2.53	8.3	28.7	
Average		39	168	507.4	3.36	10.10	2.98	13.02	44.1	
40	5	7	48	155.7	4.8	15.6	3.20	22.2	67.5	
39	5	7	35	107.4	3.5	10.7	3.10	15.3	46.8	
38	5	7	41	118.0	4.1	11.8	2.88	19.7	51.4	
37	5	7	26	72.6	2.6	7.3	2.79	10.4	31.6	
36	5	8	27	84.4	2.7	8.4	3.12	10.5	36.6	
Average		36	177	538.1	3.54	10.76	3.02	15.62	46.8	

FINAL SUMMARY

	Progeny No.	No. of Stools	No. of Stalks	Total Weight	Aver. Stalks per Foot	Wgt. per Foot	Wgt. per Stalk	Wgt. per Stool	Tons per Acre	Remarks Stalks per Stool
	1	40	207	648.1	4.14	12.95	3.00	16.20	56.5	5.14
	2	31	157	420.0	3.14	8.39	2.62	13.50	36.5	5.06
	3	35	189	538.8	3.78	10.78	2.86	15.71	47.0	5.40
	4	39	168	507.4	3.36	10.10	2.98	13.02	44.1	4.31
	5	36	177	538.1	3.54	10.76	3.02	15.62	46.8	4.89
Average					3.59	10.63	2.88	14.84	46.2	

Forestry on Oahu*

Up to June 1st of the present year, there had been planted on Oahu, under Mr. McEldowney's direction, 186,814 trees. He would have planted a far greater number had additional trees of a suitable nature been available for planting during periods when the weather was favorable for carrying on this operation.

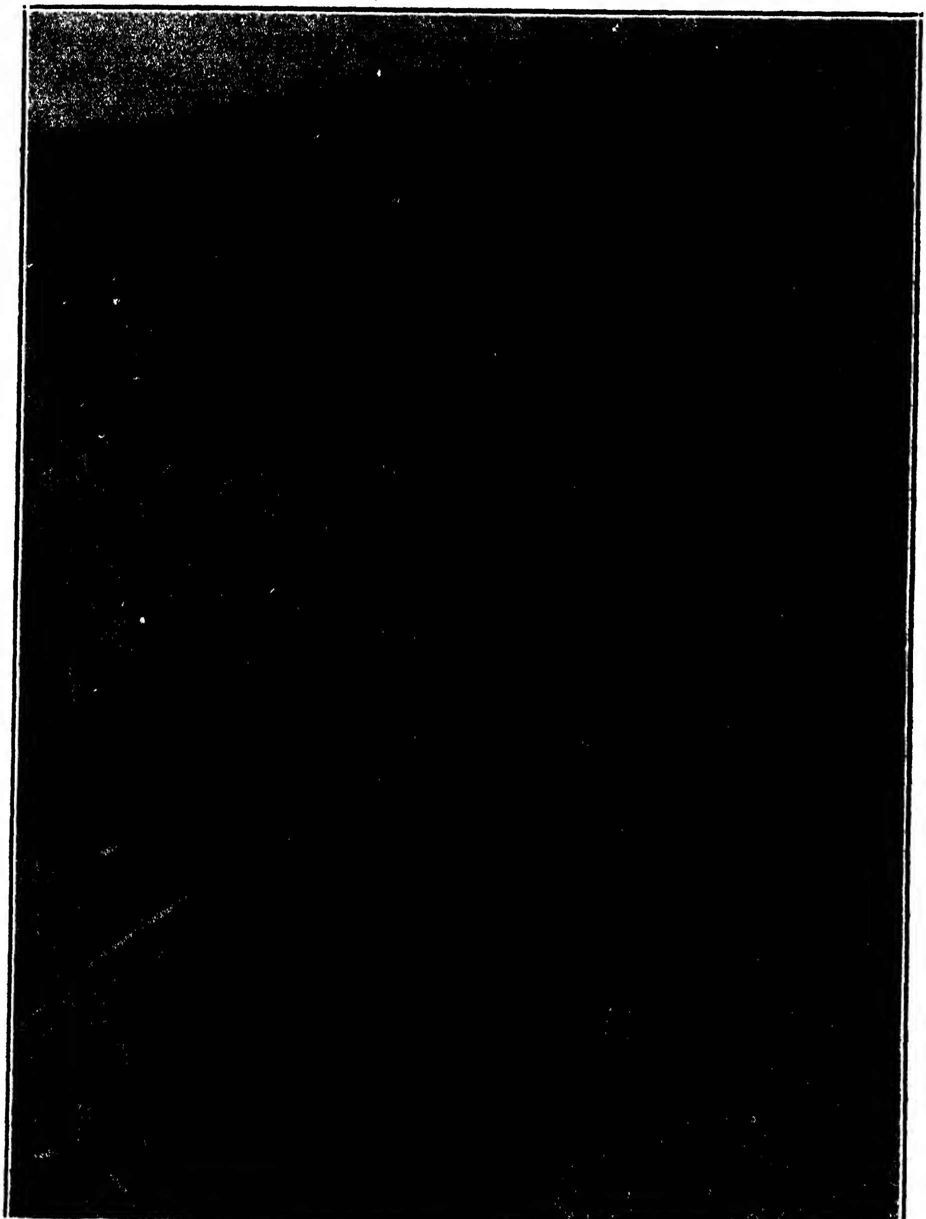


Fig. 1. *Ficus macrophylla* from seed sown in forest above Wahiawa in August, 1922. Photo March, 1923.

*From a report by Dr. Lyon, dated July 28, 1923.

In addition to planting out trees, a considerable amount of fig seed has been scattered by hand on stumps and logs in partially denuded sections of the forest. A great many sturdy seedlings have sprung up and established themselves as a result of this procedure (see Fig. 1). Large quantities of fig seed have also been sown from Army airplanes and we are justified in expecting favorable results from this operation.

In setting out tree seedlings, our idea has been to infect the forest with vigorous blood at as many points as possible. For many reasons, it has been advisable to make our first plantings at intervals along the lower border of the forest reserve. This is carrying out our general plan which contemplates the construction of a continuous barrier forest below the remaining native forest. When the trees in this barrier forest reach a fruiting stage, the seeds will be carried by natural agencies into the dead and dying forest above. At the same time, the trees will spread down the mountain slopes on to the waste lands below.

Fig. 2. *Ficus macrophylla* at Ewa Mill. Planted Feb., 1922. Photo taken June 4, 1923. Photo supplied by Mr. George F. Renton, Jr.

Before making each planting, we have obtained permission from the owners or lessees of the land to do the work, and have also received assurance that our plantings will receive the necessary protection. In most cases, we have obtained material aid from the parties interested in the land being planted. A continuous barrier forest planted under such conditions will establish the lower limit of the effective forest reserve regardless of the boundary set on the map, and will, at the same time, assure adequate protection for the reserve as a whole.

We have fostered the planting of trees on private grounds and about plantation camps. A very large number of trees have been supplied for this purpose to both sugar and pineapple companies. Then, we have induced various interests to plant windbreaks across open stretches and on the crests of gulches, while con-

siderable planting has been done on the waste lands on the slopes of gulches. If we can secure continued cooperation in this direction, the table land between the Koolau and Waianae mountains will eventually become dotted with groves of trees, while all of the gulches should be well forested. Our ultimate object is to build up a solid forest on the upper slopes of the Koolau mountains to cover all lands above the areas now cultivated and to have these forests continue down every gulch to the sea coast. In addition, the open areas between gulches will carry numerous groves. Under such conditions, the sweep of wind across the table land will be greatly impeded and this will materially affect the climate in this section of the island to the benefit of the crops grown thereon.

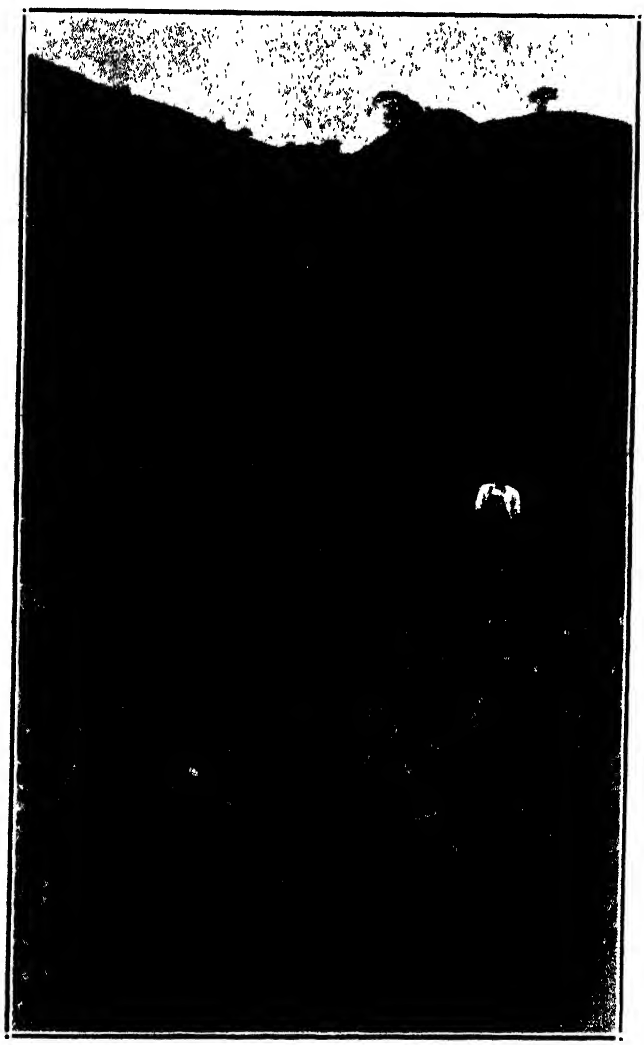


Fig. 3. *Araucaria excelsa,* Norfolk Island Pine, at Wahiawa.

Up to the present time, we have proceeded rather cautiously in the planting of new varieties of trees in order not to plant out a large number of some variety that could not succeed under the environment in which it was placed. Some spe-

cies that we expected to succeed have failed, while others considered very doubtful have shown great promise. We have quite a number of species which have proven their ability to grow under conditions prevailing on our watersheds and we can now proceed with planting operations on a large scale and with more confidence in the ultimate success of our work. Several species of trees long ago introduced but, until now, represented by only a few specimens in the islands, have proven of great merit when planted in our forests. The presence of old fruiting trees makes the rapid propagation of these species possible and we are growing large stocks of seedlings.

We are rapidly getting into the position where we know what to plant for best results and can procure an adequate supply of trees to enable us to make plantings of any size that available funds will permit.

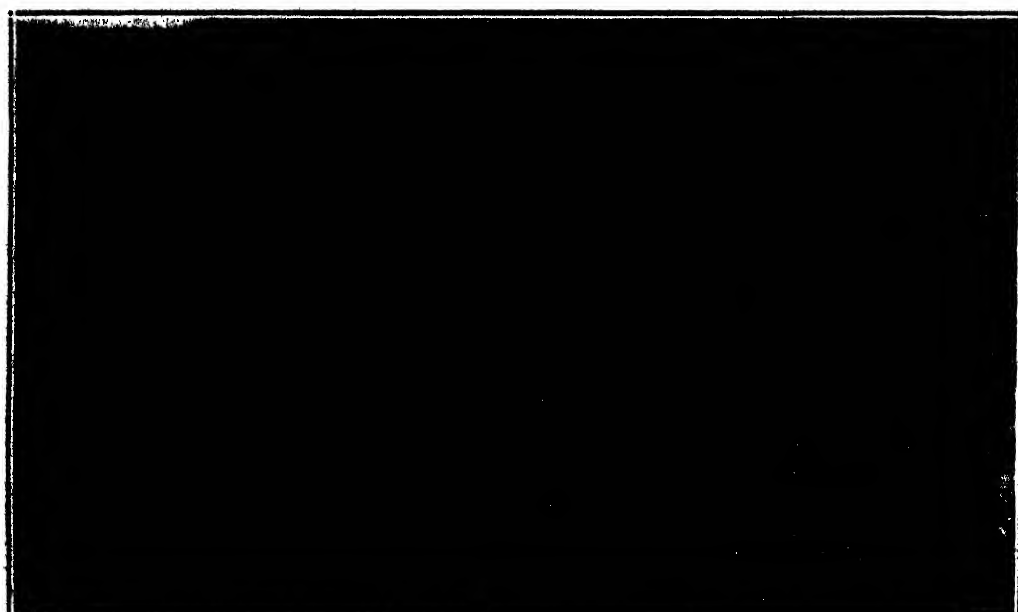


Fig. 4. Forest Plantings at Wahiawa, age 20 months. *Enterolobium cyclocarpum, Dillenia indica, Melaleuca leucadendron, Rhus semialata,* and others.

Wahiawa Nursery

Through the assistance and cooperation of the Bureau of Agriculture and Forestry, the Wahiawa Water Company and the citizens of Wahiawa, we have secured the free use of some five acres of government land in Wahiawa for a forest nursery. The Wahiawa Water Company has laid a pipe line to this nursery and supplies us with free water. Mr. McEldowney is rapidly creating here a very efficient nursery in which we expect to grow a large number of trees for distribution on Oahu. We are also propagating at this nursery for distribution to other islands high land trees which do not thrive, even as seedlings, in the low land nurseries in Honolulu and Hilo.

Forest Reserves Should Be Defined and Extended

When we began our investigation of forest conditions on Oahu, it became evident at once that the first great need was a more exact demarkation of the existing forest reserves and the extension of these reserves to take in all effective watershed areas that could be spared from cultivation.

The slopes of the Koolau mountains from Moanalua to Kahuku gather most of the water entering the artesian basins of Pearl Harbor, Waialua and Kahuku as well as all of the water delivered into the Wahiawa Reservoir and the Koolau ditch. The very existence of the several plantations around Pearl Harbor and those at Waialua and Kahuku depends upon the maintenance of the water supply gathered by this small area of mountainous country, yet less than one-half of the effective watershed area is now marked off as forest reserves.

Cattle are still invading this area at several points and at the Kahuku end they penetrate far into the mountains which have been denuded of forest in most places through their ravages. The easterly end of this area has been set aside as the Ewa forest reserve but it has not been respected as a reserve, for it seems that the boundary is at all times subject to change without notice.

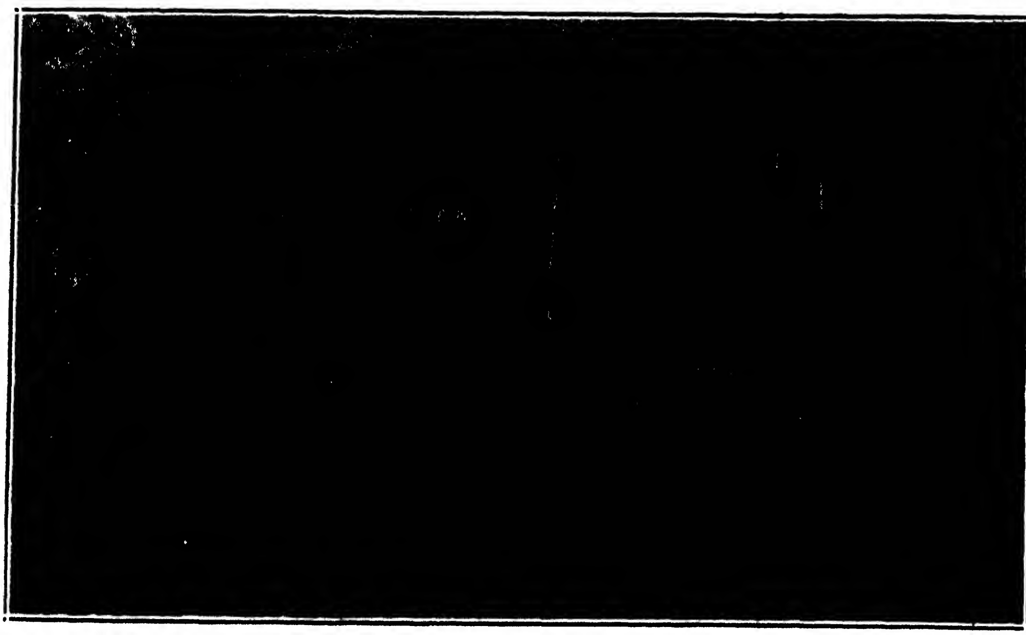


Fig. 5. Forest Plantings at Wahiawa, age 20 months. *Enterolobium cyclocarpum, Dillenia indica, Melaleuca leucadendron, Rhus semialata,* and others.

The delineation of existing forest reserves and the creation of new forest reserves are, of course, functions of the Bureau of Agriculture and Forestry. We are working in close cooperation with their officers, who fully recognize the necessity of enlarging and consolidating the forest reserves on the Koolau range.

Mr. Judd has given this matter much attention of late and has agreed to concentrate the energies of his staff on this project during the present summer. Unfortunately, the press of routine work has thus far prevented him from carrying

out his intentions, but he has just assured us that he will be on this job within a few days. We shall place all of our accumulated data at his disposal and assist him in every way possible in the field.

The ultimate goal towards which we shall strive is the creation of a permanent and well defined forest reserve including all of the effective watershed area on the Koolau mountains from Moanalua to Kahuku. Before this result can be accomplished, definite agreements must be made by the Territorial government with the owners and lessees of the various lands involved. We anticipate no serious opposition to the carrying out of this plan, but some financial settlement will probably be required by the interests now using certain portions of the proposed reserve as grazing lands.

The Forests on the Koolau Mountains Are Passing

The Koolau mountains were, at one time, covered with a heavy native forest which extended far down into the lands now devoted to pineapple culture. Years ago, the natural barrier forest was entirely destroyed and the interior forest exposed throughout the entire length of the mountain range. The native trees of

Fig. 6. *Dillenia indica* in forest planting at Wahiawa.

the inner forest, accustomed to protection, could not withstand this exposure and consequently the forest has continued to recede along its entire front. The inroads of woodchoppers and the invasion of stock opened, at many points, deep lanes into the forest. These constituted avenues for the entrance of two pestiferous plants of recent introduction, the Hilo grass and staghorn fern, which are keeping up a steady pressure on the forest, pushing back the native vegetation and preventing its rehabilitation. They quickly occupy every new opening that appears and from these vantage points invade the forest in every direction. The

native trees are quite unable to tolerate interference from man and stock or to repel the aggression of introduced plants. They quickly succumb before the forces turned against them. They possess no ability to recuperate. They regain no lost ground. Each tree that dies exposes its neighbors to added pressure from the natural forces destroying the forest. These forces are gathering momentum from year to year so that the destruction will proceed with ever-increasing rapidity.

The forest on this mountain range was, at one time, a dense rain forest that never dried out and consequently was never in danger of being consumed by fire. For many years now, the old trees have been dying off rapidly while no

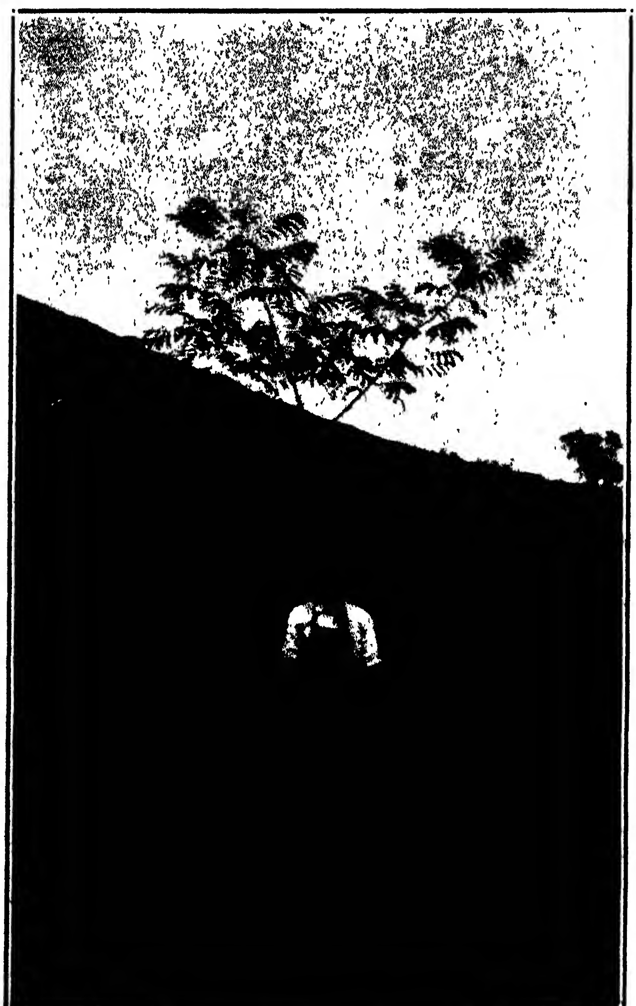


Fig. 7. *Enterolobium cyclocarpum* after 20 months in the ground at Wahiawa.

young trees have sprung up to take their places. The result is that the once dense rain forest has become a semi-open forest which dries out quickly, and for a considerable period each year assumes a state where it would burn if once a fire got started. The constantly increasing number of dead trees adds to the fire peril.

Then the ever-present uluhi fern affords the ideal kindling material in which a fire can easily start and quickly spread. This fern builds a compact blanket of material often five and sometimes ten feet thick, closely investing the trunks of all large trees and overtopping all small trees, shrubs and ferns. Only a few days of dry weather are required to dry out this fern blanket to a point where it will burn rapidly. We must expect that, sooner or later, disastrous forest fires will occur on the Koolau mountains, not only consuming the fern blanket and killing all the living trees which it has surrounded, but spreading from this blanket deep into the native forest. Several serious fires have occurred during the past year. It does not require deep and lengthy study of the situation to see that conditions on the Koolau mountains are rapidly assuming a state where a few disastrous fires will lay bare a great part of the effective watershed area.

Water and Forests on Oahu

The water problem on Oahu is very rapidly approaching a crisis. The supply available to Honolulu is inadequate to the demands made upon it, and it is now quite evident that sooner or later the city will experience a real and prolonged water famine. Not one of the plantations on Oahu obtains a sufficient water supply to give its cane the optimum irrigation and any diminution of the present supply is bound to seriously curtail the sugar yield.

The maintenance of a continuous water supply on Oahu depends not so much upon a heavy annual rainfall as upon the conservation of the water that falls during the rainy periods for use during the intervening dry spells. Oahu has no lakes and her artificial reservoirs are of very small capacity in comparison to the amount of water required. When the island experiences heavy rains, the greater part of the water quickly runs off as floods into the ocean and is lost to us. If we ascertain the total amount of fresh water now used on Oahu during a year and then make a liberal estimate based on available data of the amount of water falling in an equal period on the watersheds supplying this water, we find that the difference between these two amounts is far too small for safety and allows for no floods or other wastage.

For a continuous water supply, we must depend upon the slow run-off from our natural watersheds, and the underground waters tapped by our artesian wells.

The amount of water which will be supplied during dry periods as run-off from our watersheds will depend upon the area of these watersheds and the nature of the vegetation covering them. If the vegetation is such that it offers little obstruction to the flow of water, the run off will be rapid and our surface streams will be dry a few days after each heavy rain, but if the vegetation is such as to hold back the water, its delivery as run-off will be greatly prolonged.

The amount of water available in our artesian basins under a given rainfall will depend upon what proportion of this rainfall finds its way into the channels on our watersheds that lead into these artesian basins. If our watersheds were quite bare, permitting rapid run-off, a certain amount of water would still soak into the earth and thus enter the artesian basins, but anything that would impede the run-off would obviously increase the seepage into subterranean channels and thus increase the amount of water entering the artesian basins. It is a well recog-

nized fact that the nature of the vegetation on a watershed determines the water conserving capacity of that watershed in so far as surface run-off is concerned, but in the case of the watersheds on Oahu, it is obvious that their capacity for delivering water into the artesian basins is determined to even a greater degree, by the nature of the vegetation which covers them. In our economy, the delivery of water into our artesian basins is of more importance than the delivery of water into our streams and reservoirs.

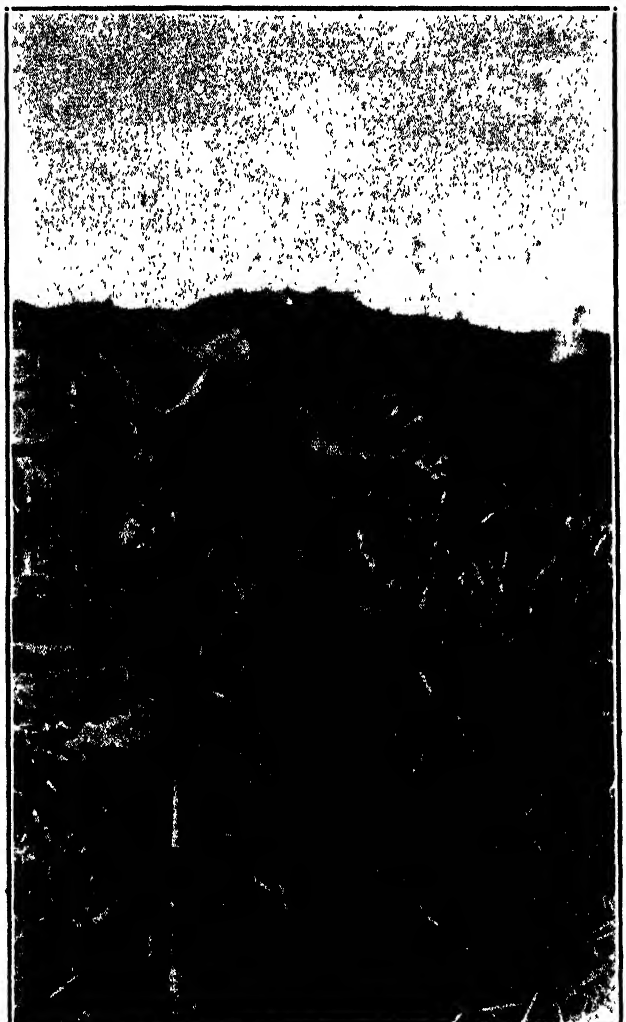


Fig. 8. *Tectona grandis*, teak-wood, in forest planting at Wahiawa.

The water supply on Oahu is drawn from a few small watersheds. These watersheds have been abandoned to the vagaries of men and the inroads of stock until now, their efficiency as water conserving agencies is greatly reduced. Uncontrolled natural forces have been set in motion which will eventually eliminate the native vegetation from these watersheds and render them barren hillsides with little or no water-conserving power.

The depletion of the forest on these watersheds has already gone so far that most of our surface streams are now dry the greater part of each year and there must be a corresponding decrease in the amount of water conserved by these watersheds for delivery into the artesian basins. We may dig new wells and new ditches but these will be of no avail to us in the long run for we cannot take out more water from underground sources than enters these sources by way of our watersheds.

Fig. 9. *Agathis robusta*, Kauri pine. Seedling was 10 inches tall when planted at Wahiawa in July, 1921. Photo taken in March, 1923.

It is a recognized fact that we are now overdrawing our artesian supply, but few people seem to realize that we are at the same time allowing the source of this supply to deteriorate. The candle is burning at both ends and we only fan the flames. Instead of spending our money to take more water out from the underground sources, we should spend this money to get more water into these

sources: in other words, cover our watersheds with a healthy, water-conserving forest.

Fresh water is a controlling factor in the development of Oahu. We have pushed that development almost, if not quite, to the limit under the water supply now available. The demands on this water supply are bound to increase, while the supply itself is decreasing and must continue to decrease for years to come, despite our best efforts to sustain it.

As fresh water is so vital to the life and industry of Oahu and, since our supply of this commodity depends so entirely upon the preservation of a few small watersheds in their highest efficiency, it is difficult to understand why popular sentiment does not demand that the government condemn the lands on these watersheds and consecrate them to the only service which they are capable of performing—that of water conservation. Continued neglect of these watersheds is suicidal, for everything fails with the failure of our water supply.

Recapitulation

From the standpoint of the sugar industry, we may analyze the water and forest situation as follows:

Not one of the sugar plantations on Oahu obtains a sufficient water supply to give its cane optimum irrigation.

Most of the water available to these plantations is derived from a comparatively small area on the Koolau mountains.

The efficiency of this area as a gatherer of water depends, to a very large extent, upon the nature of the forest covering it. This forest is rapidly deteriorating and will disappear in the course of a few years.

The watershed in question is not at the present time fulfilling the demands made upon it and its ability to fulfill these demands will decrease from year to year as its forest cover disappears.

We cannot continue to take out more water from our artesian basins than enters these basins. The only way to insure an increased supply is to insure that more water goes into these artesian basins. This water can enter only by way of our watersheds and a suitable forest cover is essential to hold back the flood waters until they enter underground channels instead of running off on the surface.

We may summarize the forestry work already accomplished on Oahu by the Experiment Station as follows:

A careful reconnaissance has been made of the watersheds on Oahu and a fair idea obtained of the condition and extent of the native forests and the size and location of areas which should be planted.

Experimental plantings, including a great many species of trees, have been made at intervals from Moanalua to Kahuku on the Koolau range and at several points on the Waianae range. These have given us valuable data regarding the most suitable trees to plant.

Seeds of the Moreton Bay fig have been sown by hand on stumps and logs in the forest. Many sturdy seedlings have sprung up and established themselves as

a result, thoroughly demonstrating the efficacy of this method of reforestation in partially denuded areas.

Nursery facilities have been secured and improved, enabling us to turn out tree seedlings to meet any and all demands.

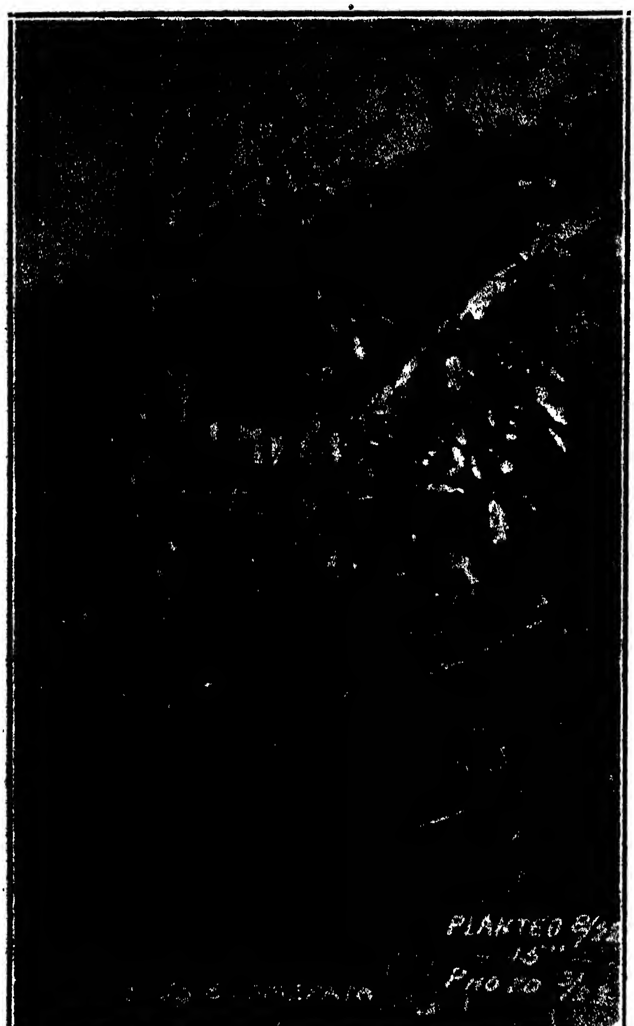


Fig. 10. *Ficus glomerata.* Seedling was 15 in. in height when planted in forest land, Helemano, August, 1922. Photo March, 1923.

An adequate supply of seed of suitable trees has been assured.

We would outline a constructive forestry policy for Oahu as follows:

All effective watershed areas to be procured and set aside as forest reserves.

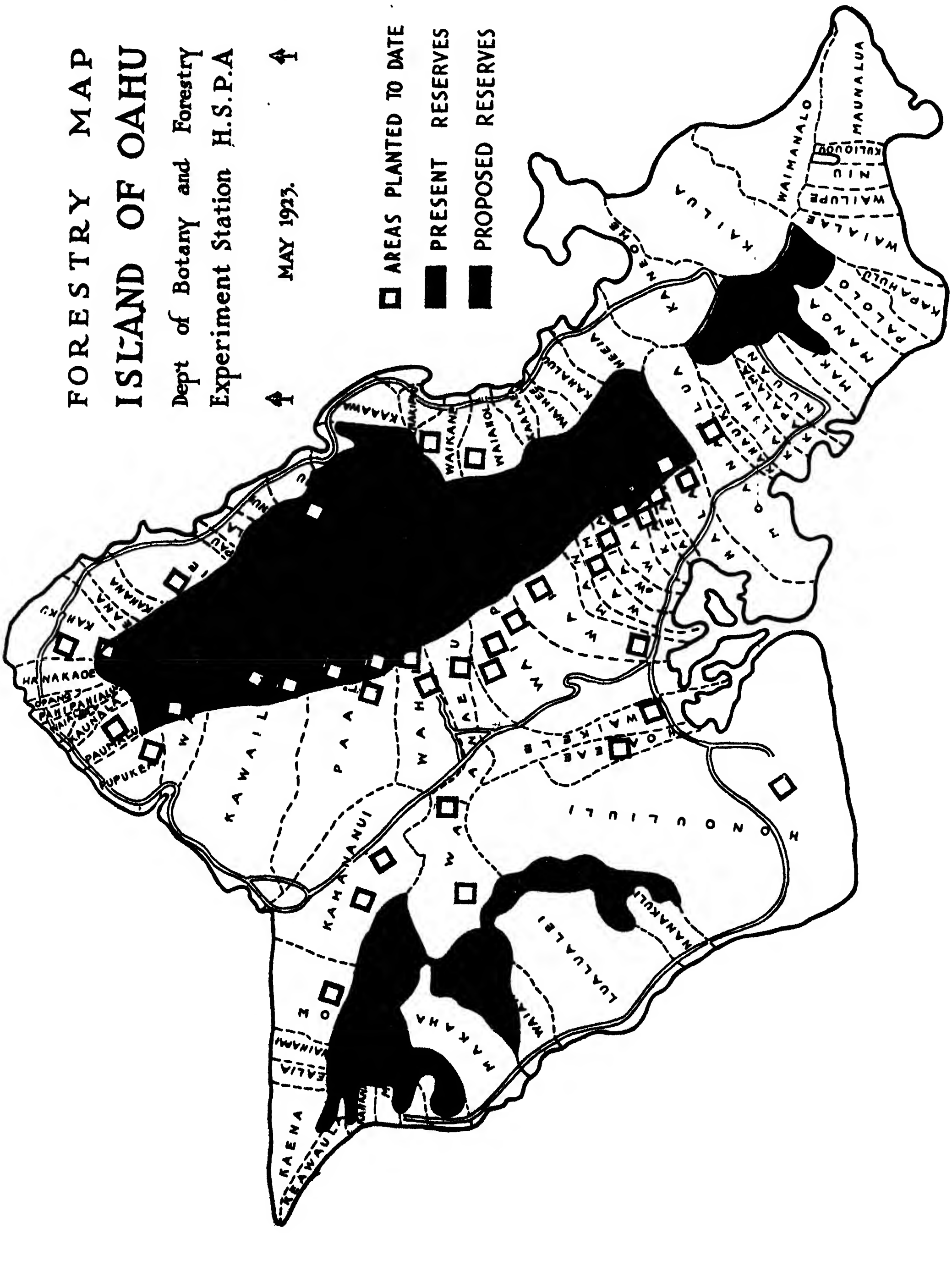
All forest reserves to be clearly defined in the field and adequately protected from injury by man, stock and fire.

Continuous barrier forests of appropriate trees to be planted within the boundaries of the reserves as rapidly as possible.

Plantings of suitable trees to be made at intervals in all denuded areas within the reserves.

Seeds of selected species of *Ficus* to be sown by hand and from airplanes throughout all declining forests.

A report prepared by Mr. Geo. A. McEldowney on the lands lying on the slopes of the Koolau mountains, which are, or should be, included in one forest reserve, follows. The status map and photographs illustrating the progress of the Oahu project are also contributed by him.



MOANALUA

Owned by Mr. S. M. Damon (Bishop Trust Company, agent).

While not in the Ewa Forest Reserve, it is adjacent to it and a portion of it should be included in this Reserve.

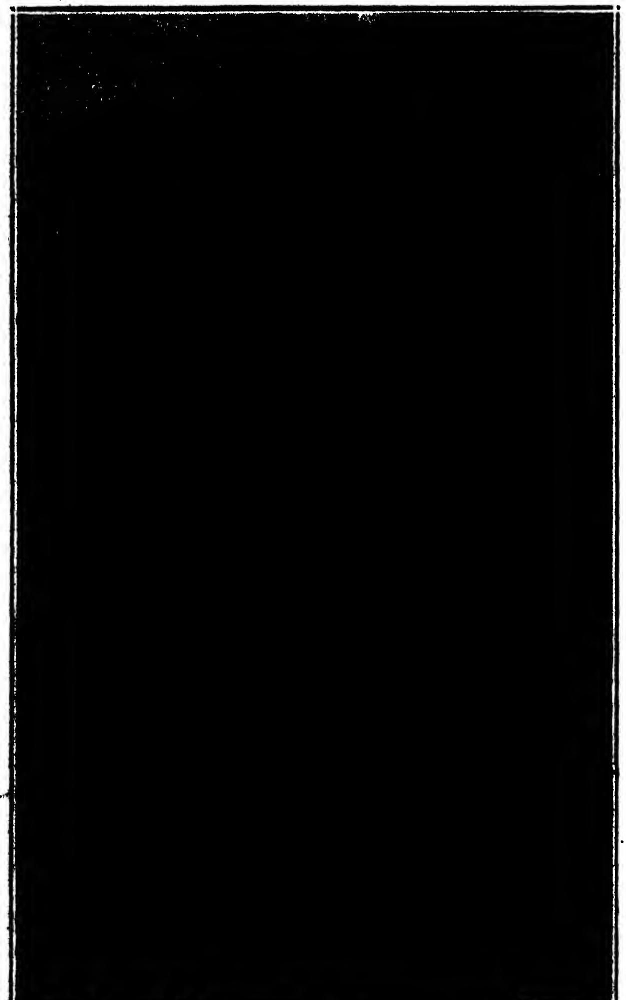


Fig. 11 *Platymiscium stipulare* in Helemano. Planted August, 1922. Photo March, 1923.

The area of this section is approximately 8,432 acres. It is a rather flat valley compared with valleys found in other sections of this Reserve. The lands above the continuation of the present Forest Reserve boundary are lower and more rolling; the sides of the gulches are very steep. It is well adapted for grazing and has been used as such for a number of years. With the exception of a few small fenced areas, the cattle have the run of the entire valley. There are a number of well built stock fences, some extending across the entire valley, but the gates are not closed, no attempts being made to confine the stock. At present there are between four and five hundred head of cattle and sixty head of horses using this range. This number will be gradually increased during the coming year, as the Damon interests are giving up their Koko Head lands and will concentrate their stock in Moanalua. In this valley there are also numerous large bands of wild hogs which are protected for hunting and have the run of the whole valley. They do a lot of damage to the undergrowth in some places; their depredations look like a cultivated field. There are also not less than twenty head of small

deer at large in this valley and they are doing considerable damage in the lower lands. The Hawaiian Pineapple Company has taken over and planted 396 acres of this land. The wild hogs did such damage to their plantings that they had to construct four miles of hog-tight fence to protect their fields.

The forests in this valley show the result of continual grazing. There are no heavy stands except in places which are inaccessible to stock. Those who have lived in this vicinity for years say that the valley stream has greater flood in the winter months, increasing in severity from year to year and dries up earlier in the summer than it did in former years, and conditions along the stream bed verify these statements.

No effort has been made in recent years to protect or increase the forest cover except a small area in the vicinity of Henry Damon's mountain house, which has been fenced and made a private Forest Reserve and a number of eucalyptus trees have been planted. In former years, prior to 1914, I believe some effort towards forest conservation was made such as the constructing of stock-tight barriers and the protecting of certain areas which were set aside as a sort of private forest reserve along the same lines as the present Government Reserve adjacent thereto. At the extreme upper portion of the valley, about four miles from the entrance, there is a water reserve and reservoir site. At this point there is a good fence across the entire valley that should be made stock-proof so as to preserve at least a portion of the valley.

A classification of these lands follows:

Cane land	1,468 acres
Pasture	3,436 acres
Pineapples	396 acres
Rice and bananas	106 acres
Fish ponds	1,000 acres
Farm lands	200 acres
Waste	485 acres
Forest Reserve	1,341 acres

SOUTH HALAWA

This section is owned by the Queen Emma Estate (Bruce Cartwright, agent).

Area and Classification:

Total area	3,704 acres
Cane lands	1,039 acres
Pineapple and grazing	894 acres
Forest Reserve, exempt	1,550 acres
Various other lands	660 acres
Waste	181 acres

Cane land leased by Honolulu Plantation Company; pineapple and grazing lands, by Charles Bellina. All leases expire September, 1940.

Forest Fences: The Forest Reserve boundary fence on the east side between Moanalua and South Halawa is all there but is sadly in need of repair. The upper boundary is the top of Koolau range. The lower boundary fence is 1.3 miles in length and was not built on the Forest Reserve line as marked by Forest Reserve monuments, but was built many years ago and is located at least one-half mile mauka. This fence crossed the entire portion of South Halawa and was stock-proof. It is now down and some sections are entirely gone. Portions of it have been rebuilt and supplemented in places by new fences to keep stock out of the new pineapple areas.

Forest Cover: Above the old forest fence where the stock did not run in past years, the forest is in fairly good shape. The small gulches are filled with kukui, while on the upper lands are found ohia, lehua and other species of native trees. In the lower part of the main valley, along the stream, are dense masses of guava. In 1922, we planted above the pineapple lands below the forest fences over 2,000 trees, of which sixty per cent were of the *Ficus* variety; the balance was of five different varieties.

Roads: The whole area is readily accessible to wagon transportation or pack train as the pineapple planters have gone over the entire area.

Fig. 12. *Ficus nota.* Seedling was 10 inches tall when planted in forest land, Helemano, August, 1922. Photo March, 1923.

Stock: At this writing, there are but a few head of stock in this section, not more than forty. They have the run of the entire main valley. The gate in the Forest Reserve is broken and carried away. The fence up the south slope is still standing but needs clearing out and repairing. There are numerous bands of wild hogs roaming over the entire bed of the valley; evidence of their presence is plainly shown by uprooted areas.

Hunting is not permitted in this section but poachers are more numerous here than in Moanalua.

Summary: To make this area stock-proof would require the construction of at least a half-mile of new fence. There are large areas between the pineapple fields which should be planted to trees. Stock should be kept out of the Reserve.

There is more land under pineapple cultivation above the Forest Reserve line than there is outside the Reserve. If this area above the line of the Forest Reserve were held out as forest land, the area remaining would be too small for profitable pineapple growing.

NORTH HALAWA

Owners: B. P. Bishop Estate.

Area and Classification:

Total area	3,470	acres
Cane lands	767	acres
Pineapples	68	acres
Forest Reserve, exempt	1,550	acres
Various other lands	124	acres
Waste and forest in gulch	498	acres

Cane lands leased by Honolulu Plantation Company; pineapple lands by Pearl City Fruit Company. Lease expires in 1940.

Fig. 13. *Ficus macrophylla* seedling fighting its way out and above the uluhi or staghorn fern in forest lands, Waipio.

Forest Fences: Forest fence constructed along line of Forest Reserve and is in good condition on the ridge and part way into the valley. In the valley, sugar cane is planted right up to the Forest Reserve line and is well protected by fence. The boundary between North and South Halawa is well protected by a steep pali. There is no fence between Aiea and North Halawa. There being no stock in Aiea, a fence is not necessary.

Forest Cover: There is no forest cover for at least three-quarters of a mile inside the reserve except the planting of 5,000 seedling trees which we made in 1921. Fifty-eight per cent of these trees are still alive but are not showing great growth on account of poor soil

and dry land; they need cultivation. Above the three-quarter mile line in the Reserve the native forest is in fair condition.

Roads: A pineapple road has been built right up to the Forest Reserve line.

Stock: There is no stock in this section except a few head owned by the Honolulu Plantation Company and they are held under control by fences.

Summary: No fence construction necessary.

More planting should be done and the trees already planted should be cared for.

AIEA

Territorial Land: Homesteads and United States Army.

The United States Army owns all of this section below the Homesteads except the Aiea Mill site, approximately 200 acres.

Fig. 14. *Ficus macrophylla.* Seedling 1[illegible] inches tall when planted in Helemano in August, 1922. Photo taken March, 1923.

Forest Reserve Lands: In Aiea there are approximately 383 acres of Forest Reserve lands. These lands are protected by good fences but the pineapple growers are, with the permission of the Board of Agriculture and Forestry, planting all the area they may select, provided they plant 125 eucalyptus trees for every acre of pines planted. The plantation interests have protested to the Board of Forestry regarding the planting of these lands to

pineapples but the Board sees no harm as they believe that the trees planted by the growers will offset the damage to the land.

KALAUAO

Owned by the B. P. Bishop Estate and Bishop Museum.

Area and Classification:

	Bishop Estate	Museum
Cane lands	604 acres	212 acres
Pineapples	39 acres	14 acres
Forest Reserve, exempt	800 acres	500 acres
Waste	125 acres	475 acres

Leases: Honolulu Plantation Company: Expires in 1940.
Pearl City Fruit Company: Expires in 1940.

Fences: There are no reserve fences across this land.

Forest Cover: No forest cover on ridge for at least a mile. Gulches well filled with kukui. A few koa and ohia occur on the north sides of the gulches.

Our planting of 2,800, chiefly *Ficus* varieties, is doing very well. Seventy-five per cent of those planted are alive. The Forest Reserve line through this section is well located.

Trails: Most of this land is in ridges—one large and two small. On the large ridge, there is a good road up into the pineapples, nearly to the Forest Reserve line. The other two ridges are difficult to traverse except on foot. There is a very short cane road up the small main gulch.

Stock: There is no stock at large in this section.

Summary: There is plenty of good land available for planting to trees and much of it is readily accessible.

WAIMALU (SOUTH)

South Waimalu is owned by L. L. McCandless.

Area: It contains an area of 900 acres.

Classification:

Cane land	Data not made available.
Pineapples	
Forest Reserve, exempt	
Other agricultural land	
Waste	

Leases: Data not made available.

Fences: Forest Reserve fence has been taken down and rolled back out of the way of pineapples.

Forest Cover: Pineapples planted for three-quarters of a mile into the Reserve. In the upper portion, above the pineaples, the forest cover is very thin and ragged. In the gulches, the charcoal burners work well up in the Reserve and wild hogs are numerous.

Trails and Roads: Pineapple roads in this section are poor but they extend well up to the Forest Reserve line. The gulches are accessible only with wagon or on foot. The trails are good.

Stock: There is no stock at large.

Summary: This section needs attention. The forest line should be adjusted. The owner has no exemption on the forest lands. The few trees, 2,100, which we planted in this section are doing well.

WAIMALU (NORTH)

Owned by the Austin Estate (Bishop Trust Company, agent).

Area and Classification:

Total area, approximately	2,411 acres
Cane lands	460 acres
Pineapples	64 acres
Forest Reserve, exempt	1,390 acres
Waste	450 acres
Rice and other land	47 acres

Leases: Cane land—To Honolulu Plantation: expires in 1940.
Pineapples—To Pearl City Fruit Company: expires in 1940.

Fences: There has been a very good fence across this section but it has been taken down and rolled back by the Japanese pineapple planters, who are planting for one mile into the Reserve.

Forest Cover: There is no forest cover worth mentioning for at least three-quarters of a mile inside the present Forest Reserve. Small gulches have scant growth in the bottom lands.

Staghorn fern, which sustains forest fires more than any other form of undergrowth, is becoming established all through this section and will in time cover all open areas below and within the forest. It makes such a dense, heavy growth that no seedlings can come up through it and it climbs over all small trees, smothering them to death.

Fig. 15. *Ficus macrophylla.*. Seedling 12 inches tall when planted in Helemano in August, 1922. Photo taken March, 1923.

The trees in an area adjacent to the Forest Reserve line which we planted in 1922, are showing vigorous growth, but need cultivation. Two thousand four hundred trees were planted here.

Roads and Trails: Pineapple roads up to and inside the Forest Reserve. In the main gulch there is a wagon road for a distance of four miles.

Stock: There is no stock at large in this section.

Summary: Pineapple people have taken considerable Forest Reserve land and are working up more, preparing to plant.

WAIAU

Owned by the B. P. Bishop Estate.

Area: 2,227 acres.

Classification:

Cane lands	325 acres
Pineapples	95 acres
Forest Reserve, exempt	1,360 acres
Rice land	28 acres
Waste and gulch	419 acres

Fig. 16. *Ficus macrophylla* growing in a camp at Wahiawa; 18 months old.

Leases: All above the Government Road to the O. R. & L. Company, who sublease to sugar and pineapple interests.

Fences: The fence on Waimalu-Waiau boundary is in good, repairable condition. The fence crossing this section to a pali in Waimano is in bad repair. Only about a third of this fence is standing and this is supported in most part by live trees and staghorn fern.

Forest Cover: Very light and scattered cover in vicinity of Forest Reserve fence; above fence, forest quite scant; some good ohia and a few fair koas.

The staghorn fern is rapidly encroaching upon the forest in this area. The very extensive stands of this fern are a real source of danger, for it burns readily and rapidly, making an extremely hot fire.

Trails: Cattle trails, well marked, up close to fence line. Good hiking trail up from Waimanu home or on the Waimalu-Waiau boundary.

Stock: No stock at large.

Summary: This is the first section where the Forest Reserve line seems to be placed well up in the existing live forest. This is a good place to observe the native forest cover, as this portion of the Ewa Reserve has been protected for some time; the trees show marked evidence of going back.

WAIMANO

Owned by the territory of Hawaii, 660 acres; O. R. & L. Company, 450 acres (fee simple), and other small holdings.

Classification:

Cane land..........................450 acres, O. R. & L. Co.
Pineapple land.............................Data not available
Forest Reserve ....625 acres

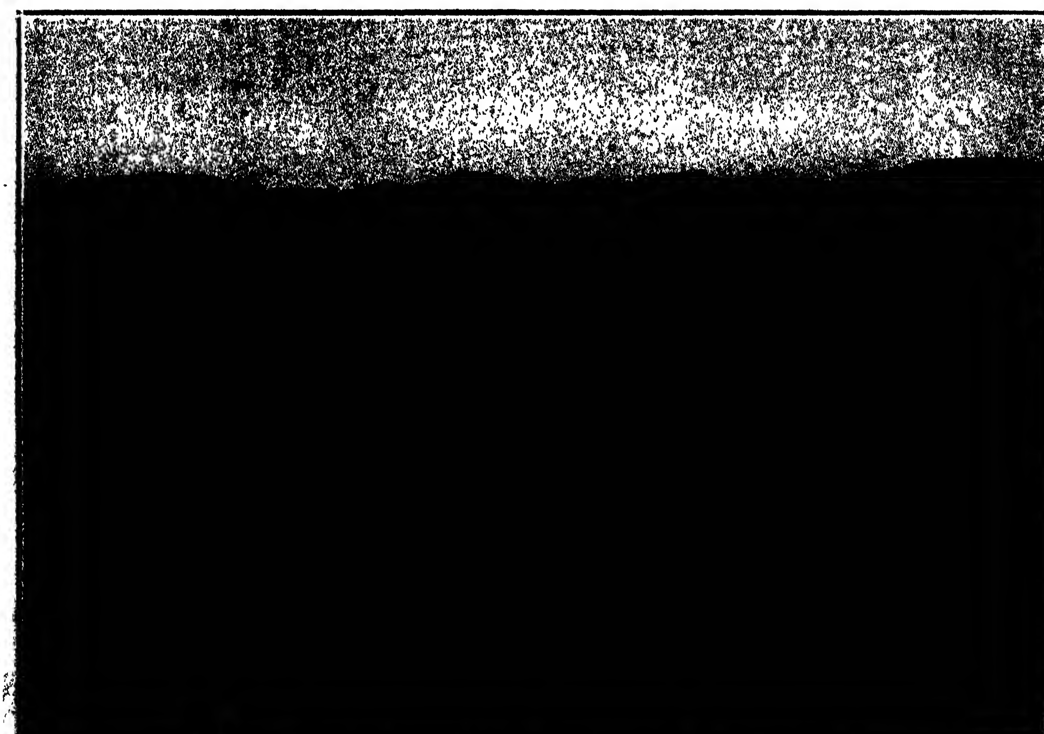


Fig. 17. Forest Reserve lands, Waimalu, converted into pineapple land. Forest cover in gulches destroyed by fire during process of clearing.

Leases: O. R. & L. Co. to Honolulu Plantation.

The Home of the Feeble Minded, located in this section, is doing good forestry work.

Fences: The Forest Reserve fence is in need of repair, only about one-third standing. Cattle may enter this section from Manana.

Forest Cover: Gulches are well filled near the Forest Reserve line. Ridges slightly covered. Good, heavy cover, mauka. Staghorn fern is getting a good foothold along trails and fence line.

Trails and Roads: All parts easily reached on foot—good trails. The Honolulu Plantation Company has a good ditch trail well up the main gulch to their upper intake.

Stock: No stock is pastured in this section.

There are a large number which wander over from Manana, as the Forest Reserve fence is all down between the two sections.

MANANA

Owned by the Oahu Railway and Land Company.

Area and Classification:

Cane	350 acres
Pineapples	320 acres
Forest Reserve, exempt	1,180 acres
Waste	Not known

Leases: Honolulu Plantation Company,
Libby, McNeill & Libby Company,
Small holders of pineapple land.

Fences: The Forest Reserve fence at 1,100 feet elevation is now down and in need of repair. No attempt has been made to keep fences in condition.

Forest Cover: The main gulch is well filled with kukui trees which are slowly creeping up the small draws on the sides. Ohias in bottom and sides rather scant and scarce. Koas on the south slopes only start about one-third from bottom and extend to one-third of the top. The whole area is about two-fifths covered.

Trails: In the gulches, wagon roads go up to the top of the ridge where the pineapples are cultivated. On the main ridge there is a good truck road well up to the top of the ridge. The approach to this road is the turn at Pearl City and through the Plantation camp at the top of the hill.

Stock: This is one of the main feeding places for the Oahu Railway and Land Company's stock. There is more stock in this section than any other place between Moanalua and Waimea.

WAIAWA

B. P. Bishop Estate, owner.

Area and Classification:

Cane land	1,740 acres
Pineapple land	967 acres
Forest Reserve, exempt	4,000 acres
Waste	3,733 acres
Other lands	190 acres

Leases: Honolulu Plantation Company.
Oahu Railway & Land Company—all above Government Road.
Small holdings.

Fence: This fence has been kept up in places where it crosses trails. It is in the same general rundown condition as all the other fences along this reserve. At times, there are indications of a few head of stock inside the reserve. The boundary fence between Waipio and Waiawa is in poor condition.

Trails: Pineapple roads and trails come close to the Reserve. The Waiahole Water Company's trails cut into the very center of this section.

Forest Cover: This section of the Reserve carries a reasonably good cover, the majority of the trees appear to be strong and healthy. The gulches are well filled with koa, ohia and kukui, also numerous stands of mango, breadfruit and bamboo. There are not as many wild hogs in this section as are found in other sections at the same elevation.

Stock: At certain seasons of the year there are indications that stock breaks through from Manana (O. R. & L. Co.'s cattle) and have the run of this land in the vicinity of the Forest Reserve fence.

Summary: The plantings we made in this section amount to 4,000 in several different locations and all are doing well.

WAIPIO

John Ii Estate, owner.
Area: 16,250 acres.
Classification:

Cane lands	5,043 acres
Pineapple lands	4,712 acres
Forest Reserve, exempt	5,000 acres
Rice and kula	302 acres
Waste land	1,193 acres

Leases: Oahu Plantation Company,
Pineapple lands to Hawaiian Pineapple Company and Libby, McNeill & Libby.

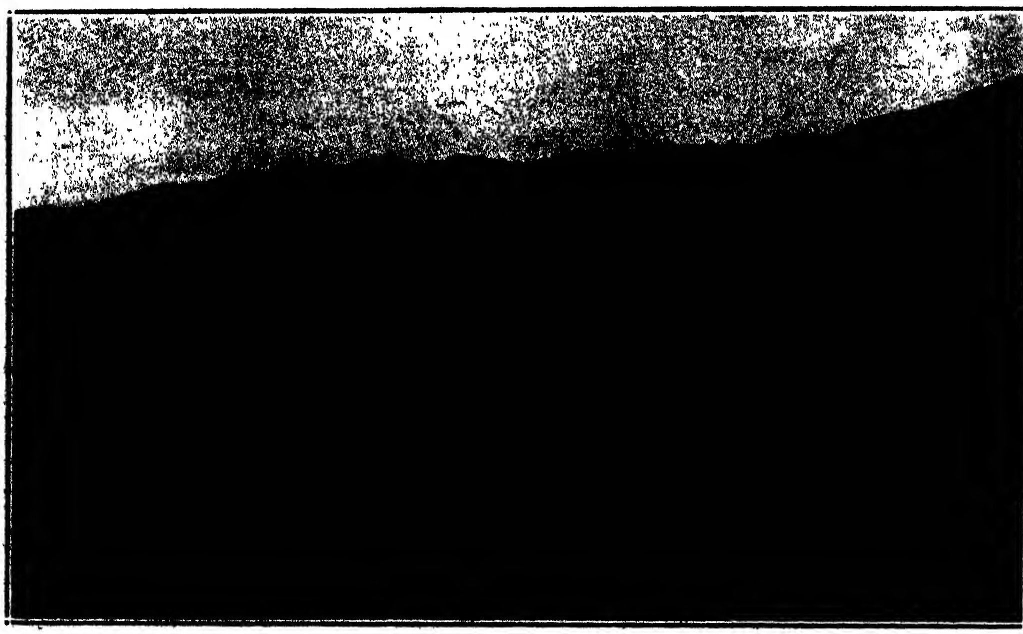


Fig. 18. Native forest in pocket back of Kahuku.

Fences: Forest fences across this section are in better condition than any other part of the line of Ewa Forest Reserve. Ii Estate maintains them and also a large area is fenced outside the Reserve for the protection of an area planted to trees.

Forest Area: Area inside of Forest Reserve fence well covered; gulches filled with kukui type of forest. The ridges are heavily covered in places with koa and lehua. In the past, this section has been worked over for wood. Numerous wood roads and trails are scattered over this area. Apparently only broken and fallen trees were used for wood; as the result of this, many of the trees now standing are quite fine specimens.

The owners of this section have been engaged in reforesting much of the land outside the Reserve. They have spent considerable money in planting and caring for a large area of eucalyptus trees. They still maintain a few men, growing and planting.

We have planted up several small areas in this section on several different ridges and slopes. These trees are all growing well.

The staghorn fern is a serious obstacle to planting in this section. It is also a serious menace to the remaining forest as it dries out quickly and burns like tinder.

Trails and Roads: As this section is devoted to pineapple culture well up to the forest line, wagon roads extend up all the valleys and on most of the ridges.

Stock: There is no stock at large in this section.

WAIANAE UKA

U. S. Army lands. This entire area is devoted to military use.

The area is fenced on all sides.

No stock is permitted to be at large.

The area included in forests is fully protected and additions by further plantings are being carried on.

The Army has planted about 20,000 of our trees in this area. Better than 60 per cent of these are now growing.

WAHIAWA

Owners: Territory of Hawaii..152 acres
Waialua Agricultural Company........................100 acres
Wahiawa Water Company...................................
A number of homesteaders and other small holdings.

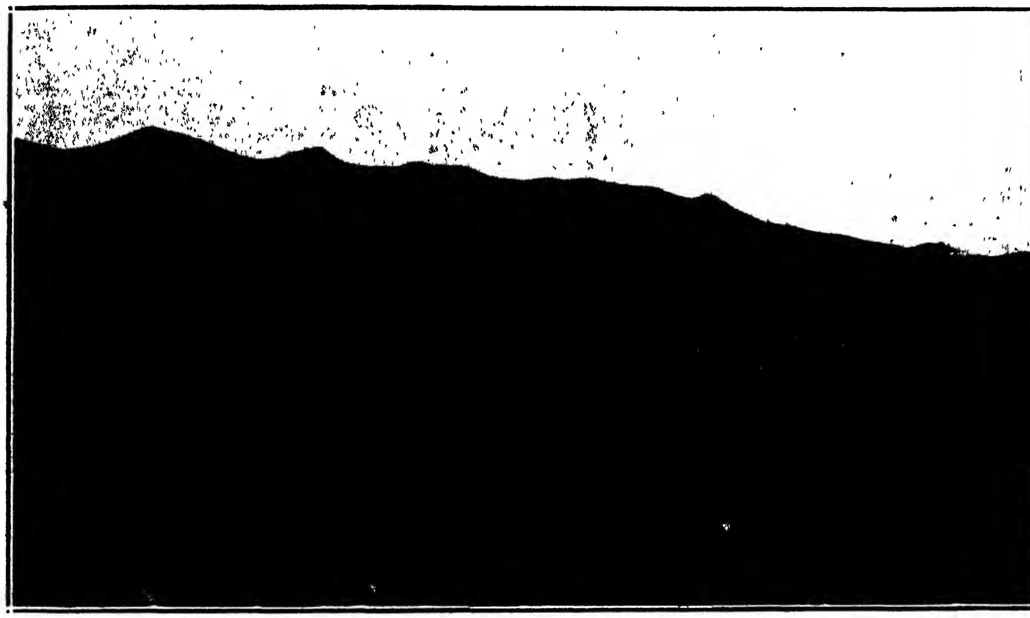


Fig. 19. This area adjacent to that shown in Fig. 18 carried the same forest cover until it was destroyed by stock.

With the exception of a few hundred acres of cane, all the agricultural land in this section is devoted to pineapple culture. There are two dairies operating here. Their stock is kept in herds. At times they get away and wander over into the U. S. Army lands where they have done some damage to trees planted by us.

Fences: There are no Forest Reserve fences across this area and from all indications the fence was never constructed beyond the boundary of Waianae Uka and Wahiawa. The Wahiawa Water Company has a water reserve adjacent to the Forest Reserve line which is kept fenced and all trespassing is prohibited.

Forest Cover: Wahiawa above the Forest Reserve line is well covered, and with the plantings made by us below the present Forest Reserve line, Wahiawa is well taken care of. There is room for more plantings. Hand sown *Ficus* seed is getting a good start in this section.

Trails: Pineapple and old wood roads reach into all parts of this section. The Wahiawa Water Company's ditch trail, which is up the south fork of the north branch of the Kaukonohua stream, will take one up into the very heart of this section.

Stock: There is no stock at large.

PAALAA

Owned by the Waialua Agricultural Company and the B. P. Bishop Estate.

Classification:

Sugar cane	800 acres
Pineapples	3,600 acres

Fences: In 1906, there was a fairly good fence across this section, well up into the forest between the 1,200 and 1,600 feet contours. There are only traces of this fence to be found now. If it is to be reconstructed, the Forest Reserve line should be brought much lower, at least to the limits of the present pineapple areas and to include the areas which we have already planted, at least 100 acres.

Forest Cover: The forests in this section have been protected during the past decade and are now in fair condition. Logging for firewood has been rather hard on some portions during the past few years but they are recovering and have opened up an area, giving us a chance to plant in sheltered places.

Trails and Roads: Pineapple roads and wood roads have opened up this section so that all parts are accessible.

Stock: There is no stock at large.

KAWAILOA

B. P. Bishop Estate, Owner.

Area: Total area 14,250 acres.

Classification:

Cane lands	4,475 acres
Pineapple lands	2,200 acres
Forest Reserve	None
Planted to forest	1,000 acres
Waste lands	3,200 acres
Pasture, etc.	3,375 acres

Leases: Waialua Agricultural Company.

Fences: At one time (prior to 1910), there was a good forest fence across this section above the 1,000-foot contour line. On account of the withdrawal of stock from this land, the repairs on this fence were not kept up so that little of it now remains.

Forest Cover: There are some good stands of koa and ohia in detached areas. Staghorn fern is very abundant, covering large tracts of land.

The Waialua Agricultural Company has made very extensive plantings of timber trees and now has a commercial forest covering approximately 1,000 acres. A considerable part of this area was planted some ten years ago and many of the trees have attained remarkable size. Various species of eucalyptus constitute the bulk of this planting.

The Waialua Agricultural Company has been getting firewood out of the native forest and we have planted 7,880 trees in some of the areas which have been cut over. These are making good growth.

Trails and Roads: Wagon roads built for logging purposes extend well up into the native forest. The Hawaiian Pineapple Company is now opening up considerable areas for pineapple culture and is improving the roads.

Stock: There is supposed to be no stock in the mauka lands of this section. They do break through the boundary fence from Waimea, however, and work their way for a mile or so into Kawailoa. On one occasion, they destroyed numerous trees which we had planted.

WAIMEA

A. W. Van Valkenburg, et al, owners.

Area: Total area, approximately 5,710 acres.

Classification:

Ranch and waste lands	5,310 acres
Pineapple lands	400 acres

Leases: Ranch lands to O. R. & L. Company.
Pineapple lands to various lessees.

Fences: A stock-proof fence is maintained on boundary between Waimea and Kawailoa. Pineapple lands all fenced to keep stock out.

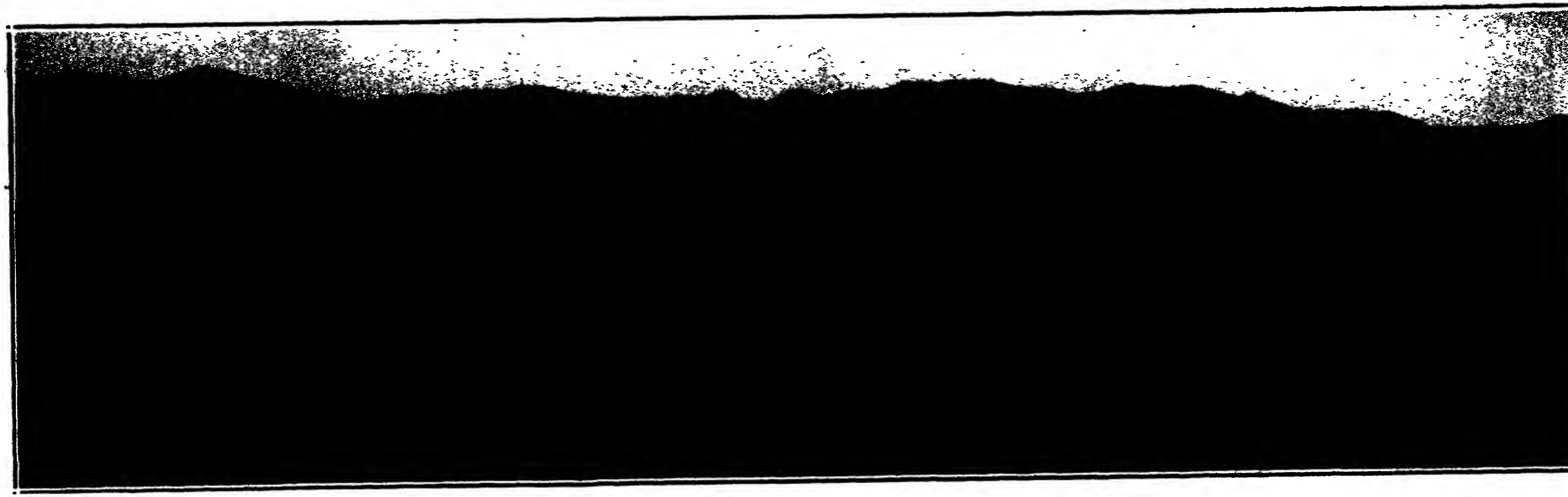


Fig. 20. Campbell Estate lands at Kahuku, a small portion of which was fenced and planted in 1922. This area is to be made a part of the proposed new Forest Reserve.

Forest Cover: The forest cover is good only in spots and, upon examination, it is found that these good spots are on steep hillsides or flats inaccessible, or nearly so, to the stock which has the run of this entire area.

In 1922, we planted 2,500 trees in protected places in the lower lands of this section. In July, 1922, I made a trip well into the interior of Waimea and scattered seeds of *Ficus macrophylla*. A few months later I found numerous seedlings which had taken hold and were growing.

Stock: This area is made to do heavy duty as grazing land. The stock penetrates to the very crest of the Koolau mountains.

KAHUKU SECTION

Comprises the following land divisions:

Kaunala, Pahipahialua, Opana, Hanakaoe, Kahuku, Keana, Malaekahana, owned or controlled in main part by the Campbell Estate, and has an approximate total area of 15,000 acres.

Classification:

Cane	2,310 acres
Pineapples	2,513 acres
Pasturage and other lands	10,204 acres

Leases: O. R. & L. Co., who sublease to various lessees.

Fences: The only fences on these lands are for the protection of sugar cane, pineapples and one small section of forest land fenced in 1922 by the Kahuku Ranch and O. R. & L Co.

Forest Cover: There still remain in the upper lands some of the native forests in surprisingly good condition when one considers that this entire section has been used as grazing land for many years. In the upper forests, one sees larger koas than are found in any other part of Oahu. This land would probably come back into forests to some extent if given protection from stock.

In Kahuku, a small area (25 acres) was set aside in June, 1922, fenced and planted. All these trees are doing well. In the one year that this has been fenced you can see an improvement in the undergrowth.

Trails and Roads: This entire section is quite accessible; some pineapple roads reach well up on the ridge while in the gulches and on the higher levels there are good horse trails.

Stock: Outside of the areas fenced off for cultivation and the 25-acre forest tract mentioned above, stock has the run of this entire section up to the very crest of the Koolau range. As these lands join Waimea on the crest of the ridge, it can be seen that the entire watershed at this end of the island is given over to grazing.

H 109 at Kaiwiki

While we do not recommend H 109 cane for high elevations, we find much interest in the showing it has made at 1,800 feet elevation at the Kaiwiki Sugar Company. The following data, on a small area of this cane recently harvested, has been supplied us by Mr. James Johnston, Manager of that plantation:

Cane, H 109;
Second ratoons;
1,800 feet elevation;
Area, .322 acre;
Tons of cane, 13.03;
Brix, 18.7;
Pol., 17.4;
Purity, 93.0;
Tons of cane per ton of sugar, 7.41.

H. P. A.

Overhead Irrigation at Hawi

By J. S. B. Pratt, Jr.

A very detailed study was made of the overhead system of irrigation now being installed at Hawi. Manager Henry Hind very kindly supplied data and every assistance possible in the inspection of the system.

Overhead irrigation is not new to the Islands or to Hawi. Maui Agricultural Company had a small test some years ago. Makaweli has had a small field of about six acres under it. Mr. John Hind, until last month manager at Hawi, has been experimenting with it for years in a small way. In fact, Hawi has been a center for experimenting in new loading systems, implements, etc. But Manager John Hind has gone beyond the experimental stage with overhead irrigation, and has installed a system that will change his entire plantation conditions. He has been ably assisted by his sons, Henry Hind, now manager; Oswald Hind, head overseer; by the chief engineer, W. B. Woodside, and the rest of the plantation staff.

Hawi Mill and Plantation Company is on the northernmost point of the island of Hawaii, the north Kohala plantation. It is subject to strong dry winds and dry weather. The soil is a very porous granular clay to loam.

The plantation has a cane acreage of 3,750 acres, 2,073 of which are irrigated. Due to labor and water shortage, this year's crop is very small.

To understand what the overhead system means to Hawi one must really know what Hawi has been up against. All of the Kohala plantations have a shortage of water during the summer months. Due to the porous nature of the soil, irrigating under the old system is a difficult problem. Water reaches with difficulty to the end of a line of 30 feet. This means a loss of water in both ditches and lines from seepage. Under the old contour system, it required 1,300,000 gallons of water per day to take care of a 100-acre field. Under the overhead system 750,000 gallons are estimated as being the required amount. At present, many of the fields have had to be neglected because of labor shortage, and owing to the poor stand in the ratoons, caused by the inability to get on water after harvesting, and to the lack of water to properly care for them. It is expected that this condition will be entirely overcome by overhead irrigation. At the end of this article are given the advantages and the disadvantages of the system as the writer sees them.

Knowing Hawi's conditions, and seeing how perfectly the system is working, one feels justified in commending the system for Hawi even though the initial cost is a big objection, but which is really the only one that could be raised. After seeing the system work, it is the writer's opinion that it could be used to advantage in Hamakua and many plantations in the Islands.

Hawi this year made a rational move. Mr. Hind's 2-acre experiment that he has had a number of years, proved to him the merits of the system Already a 100-acre field is installed. Another 88-acre field is being laid out. Next year, of

their entire plant cane area of 500 acres, possibly half will be in the new system if this year's extensive trial justifies such a course.

The costs at first ran high, naturally, as much experimenting had to be done. The system when done on a large scale so that pipe, fittings, etc., can be purchased on a large order, can be installed for a cost of between $150 to $175 per acre. There are so many factors that enter into this, largely the nature of the terrain, that no set rule can be made for each field. In fact, the system must be modified for each field, and with a 25-foot contour map of the field, one can do practically all of the figuring of the installation in the office.

The installation of the overhead irrigation system is an engineering rather than an agricultural problem. After it is installed, the field is handled in cultivation as an unirrigated plantation would be, except that moisture can be absolutely controlled during the dry season.

Laying Out the System

As has been said, every field is a problem in itself, and largely an engineering problem. A contour map of 25-foot intervals is prepared, and from this practically the whole system can be laid out in the office.

Field Hoea No. 12, the 100-acre field first installed, was an even field, at an elevation of 340 feet. To give enough head, 920 feet of 6-inch main line was laid back to the 400-foot level. About 30 pounds pressure is required at the trunk line.

In the new field, No. 10, of 88 acres, it was figured that a saving could be made instead of running so far back to give the initial head, by placing an electric pump at the head of the main line, to give a pressure of 40 lbs. The saving in pipe would about pay for the pump. The new field has a branch main line.

The Overhead System For Ideal Layout

An ideal field layout would be a rectangle with the trunk line going down the center, and laterals branching from its both sides at a distance of every 56 feet (14 lines of cane, 4 feet wide). The standpipes would be 60 feet apart, and the pipes to supply the system would have to be figured from tables of pressures. Optimum length of laterals would be 400 feet.

Tables of Pressures

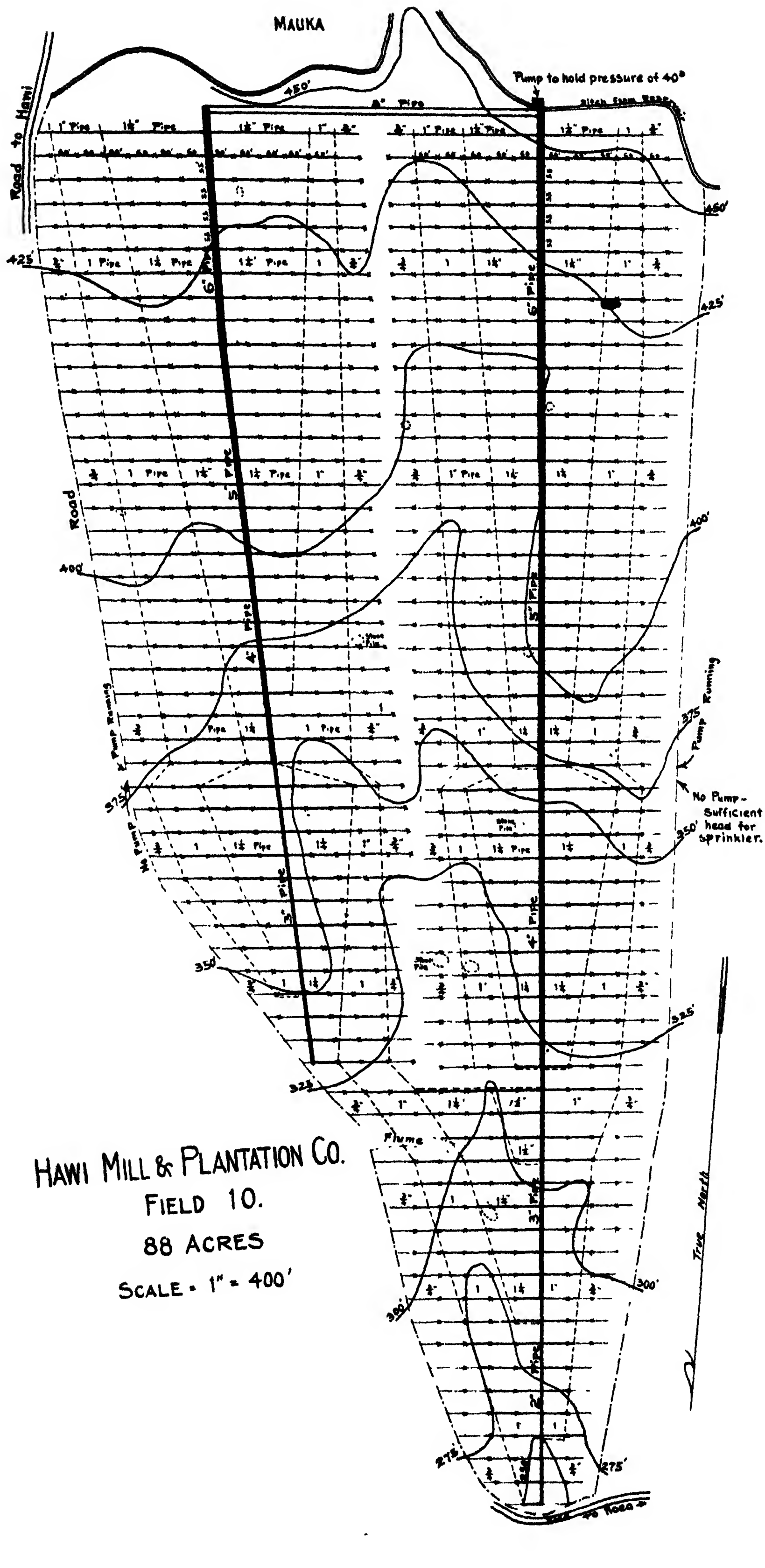
Weston "Friction of water in pipes."

The Pacific Woodstave Pipe Company's literature.

Remco Pacific Woodstave Pipe Company's literature.

These three works have been consulted for pressures for the conditions in question. The plantation has prepared a chart for their use, to show what reductions to make in sizes of pipe for different distances on lateral and main line and still give 30 lbs. pressure at the trunk line.

Perhaps the best way to describe Hawi's installation is to take it up in detail. Pictures were taken to bring out details hard to describe, and these will be seen at the end of the report with a map of ~~the new field~~ (Field 10) now being put in.



HAWI MILL & PLANTATION CO.
FIELD 10.
88 ACRES
SCALE - 1" = 400'

Covering of Pipe.

Hawi covers the main line pipe only. A furrow is made, the soil shoveled out. Then a subsoiler, pulled by a two-mule team, one animal on either side of the ditch, loosens more soil, for further shoveling. Here a Martin road grader, as used by Kilauea, could be used to advantage, unless there were too many rocks. The lateral pipes are not covered, but are laid beside the rows of cane so as not to interfere with cultivation.

The field is to be run for one plant and four ratoons, or ten years, and the pipe will be so depreciated by that time that when the field is plowed again, the value of the lateral pipes will count for little. With Kohala's salt air, they will be about rusted out anyway, so that plowing can be considered at that time. The main lines are only just buried, possibly 8 inches. Laterals will not give trouble in the harvesting as cane will be flumed. They can get water from the box at the head of the main pipe.

Main Lines

The size of the main line depends on the contour, the heads, length run, etc. The first field (Hoea 12) laid out was as follows: From an elevation of 398.6 ft. a 6″ woodstave pipe was run 920 feet to the top of the field, elevation 340.2 ft. The pressure here of 25 lbs. is reduced to 14 lbs. when all sprinklers for a day's irrigation are in use. From here the main line continued as 6-inch for 2,500 feet, to elevation 200.3 ft., head 197 ft. From then on to the bottom of the field, 1,400 ft. more, a 4″ wood pipe was used.

In field 10, shown in Figure 1, the main line is not run back to give head, but a pump is installed to hold 40 pounds pressure. One main line has 6″ reduced to 5″, reduced to 4″, reduced to 3″, then to 2″. A large lateral 8″ carries to the other main line. This pipe could have been smaller, but was ordered before the pump idea was decided upon, to be the pipe run back for head. The line is reduced from 6″ to 5″ to 4″ to 3″ to 2″, as shown on map of field in Figure 2.

Pump

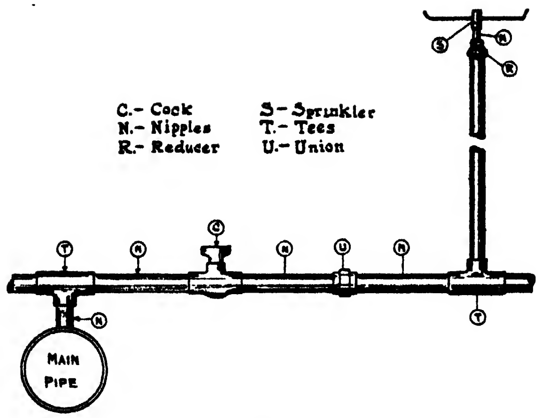
It will be noticed that the pump will only be in use for the upper half of the field. The lower half will have enough head of its own.

Lengths of Main Pipe

The woodstave pipe is made in various lengths. It is of redwood or spruce and covered by tarred cloth. Several companies make such pipe, and there are local agencies for the pipe in the Islands who can supply details as to cost, friction, etc. It was decided that the wood pipe is the best for the main line. Laterals are well galvanized.

Fittings

No set fittings can be given, because the requirements of each field would be different. There are no valves on the old field. The new field has several large 8-inch and 6-inch valves at the head of the main line by the pump to let water go into the two systems. Elbows, nipples, reducers, unions, and tees are all needed on the lateral. For example, from the 8-inch pipe line to the first standpipe would be needed the following: Fittings run into considerable money, and very careful figuring will make a saving.



Screens

A very ingenious device has been worked out by Engineer Woodside to keep the pipes from clogging with dirt, "limu," etc. A box flume carries the water from the main ditch. A box one foot deep settles all the silt. This box is lower and has a small 6-inch gate to sluice the mud out. Then comes in the flume, a waterwheel working a set of scrapers which scrape all moss, etc., that might settle on the screen. The screen is of a very fine mesh. All water passing through the screen, then, into the main line is quite free from foreign matter, etc. Later, of course, when the lateral pipes rust, there will be some sediment in the pipes, but as the standpipes are ten feet high, the sediment could be blown out occasionally at the end of the laterals.

Gauges

A pressure gauge is installed at the head of the field on the first lateral, but others are placed in occasionally to check the pressure on the various lines.

Pressures

A pressure of 30 lbs. is wanted at the main line.

Laterals

Hawi has a good wind that assists them in distributing the spray from the nozzles. They have placed their laterals 55 feet plus off the main line, probably 56 feet, as the lines follow the rows of cane, and as the rows of cane are planted 4 feet apart, 4 times 14 equals 56 feet. Standpipes are 60 feet in the laterals.

The amount of water going into the lateral is regulated by a one-way cock. They found that two one-way cocks were cheaper to put in than one two-way cock, where laterals go both sides of the main line.

The size of lateral pipe varies from 2 inches down to ¾ inch at the last standpipe.

Laterals are not buried.

It is very essential in order to make a saving in length of pipe for the laterals, that they run perpendicular to the main line, and naturally, then, the rows of cane have to follow the same way because the pipes would interfere with cultivation. The perpendicular would be the shorter line. On a lateral 700 feet long, as in

the first field laid out at 90°, if it came out at 45° instead of 90°, the lateral would have been 989 ft. long. At 60° it would have been 808 ft., and at 80° it would have been 709 ft.

Optimum length of laterals is thought to be 400 feet, more or less, depending upon the individual layouts.

Standpipes

By roadways where the prevailing wind catches the spray, the standpipes are only 5 feet high. They are 10 feet high in the rest of the field. When the field was first tried out, the standpipes were made 5 feet, so that adjustments could be made very quickly on the nozzles. When the system worked well, they were lengthened to 10 feet. Hawi's cane is much shorter than at some places, and the strong winds there give a very good distribution. Occasionally it was found that the spray at the road would not be given equally so that there were a few dry spots. The field planted is D 1135, 3 feet high and an excellent stand, showing that the water is well distributed under their conditions.

Skinner System.—To give a better distribution by the roads where the wind was more variable, the Skinner system of an overhead pipe for the first standpipe was tried with success. This was set back from the road. It clogs more than their type of sprinklers.

Standpipe.—All methods of placing these were tried, on equilateral triangles, on squares, etc., but the system decided on finally has the first standpipes 5 feet high, at the edge of the road by the main line (where the wind is in that direction), and then 60 feet in the next standpipe, so that they are all in a row. The reason the standpipes are 60 feet apart is to save cutting pipe, which comes in 20-foot standard lengths. The standpipes inside, as has been said, are 10 feet high and are not guyed. By each standpipe, however, is a piece of 2 by 3 driven in, to which the pipe is wired.

Each lateral is numbered on this wooden block, so that a lateral may be referred to, or a record system be kept on the irrigation.

Size of Pipe of Standpipe—Three-quarter inch pipe with bell reducer to 3/8" and nipple to the sprinkler.

This distribution of standpipes is working nicely at Hawi. Places without wind and with taller cane may have to have them higher and closer. Makaweli had them 80 feet apart and 25 feet high, guyed, but Manager Baldwin there, believes that they should be 60 feet apart. The higher, the more difficult, of course, in removing the sprinklers.

Sprinklers

All types of sprinklers have been tried, but none have done so well as the one Hawi makes in their own shops. It is made of brass and costs 45 cents. A detail of it is given in Figure 3 as a picture. The features of their sprinkler are these: There are three holes at 45° for the water to force itself in the revolving part. The upper portion has two nozzles at 45°, and about 6 inches long, and the point is tapered to force the water further.

The number of sprinklers per acre at 56′ x 60′ is 13.

The water that leaks through the top of the sprinkler gives a better distribution near the standpipe.

A new feature to be tried is a washer to be placed in the lower part of the sprinkler, with various sized holes to regulate the pressure at each nozzle. To establish what size washer to use, a pressure gauge is put on the standpipe, and from a table they have prepared, the opening in the washer necessary to give the required pressure at the nozzle is found.

The amount of water to go through each sprinkler is calculated at 4 gallons per minute per sprinkler for 12 hours.

Irrigating

The water is turned on for 12 hours in one battery of about 160 sprinklers. There is a day man and a night man. The night man turns on another battery. This they figure is equal to 1½-inch irrigation.

In Field Hoea 12, the 100 acres are done in 7 days by the two men. There is no actual data as yet on the amount of water, but they claim 750,000 gallons will be what 100 acres of overhead irrigation requires.

Clogging

There has been no trouble so far with clogging of the sprinklers. The fine mesh wire screen at the head of the main line keeps out foreign matter, and no rusting has yet taken place. But in big cane, if one clogs, a forked stick can be used to quickly raise the upper part of the sprinkler, and the water coming at 25 pounds pressure will blow out any foreign matter; otherwise, the pipe will have to be unscrewed.

The clogging is one of the few objections that could be raised to the system, but Hawi has apparently thought out all of these troubles in advance. The sprinkler in two parts with the screen to strain all water entering, may overcome any future trouble.

Planting

The field is plowed, harrowed and made ready for furrowing. The main line pipe is installed and covered, and each lateral is made one length with cock on each. The field is then planted in straight rows, 4 feet apart, and perpendicular to the main line. The laterals follow every fifteenth line in, close to the cane, so that line can later be cultivated.

The cane could be planted with the new Larsen, Moler or Broadbent unirrigated land planter. If planting is done in wet weather, there need be no haste in getting the laterals in. The laterals are not placed in until the cane is planted.

Two men working together on a lateral can put in standpipes, sprinklers and 2,250 feet of lateral in one day. The lateral pipe is placed in the field before planting but is not screwed together. It is not buried.

Roadways

Roadways should follow main lines, for laterals have cocks to be turned.

Labor in Irrigating

As has been mentioned, one man runs a battery of 160 sprinklers for all day. The night man changes to a new set. This leaves the man free to hoe, fix sprinklers in trouble, etc.; two men seven days or 14 men for 104 acres. They could take more acreage especially while cane is small. In the old system, one man

hardly did three-quarters to one acre with big water, or some 130 men for one round of irrigation, instead of 14 in the new system.

Costs

Costs were not gone into very thoroughly, as the costs would vary considerably for each field installed. A plantation installing an overhead system would have to figure it out on an exact cost basis for each field. The first field of 100 acres cost $168 per acre, but on a large scale, the cost could be made for $150, it is believed. The main expense is in pipe and fittings. Installation and hauling should not be much over $12 per acre.

The cost is the big item to criticize in the system, but $150 per acre, to cover a ten-year period is not a bad item, especially when one looks at all the advantages which are given at the end of this article. The saving of labor alone soon pays for the initial cost.

Mistakes and Future Improvements

Naturally, going into a big proposition like this, many little details had to be worked out. Many improvements have been made, and more will no doubt come later.

First. The mistake made in the first field was that the laterals were too long. They were 700 feet and over. The optimum length of the laterals should be 400 feet instead.

Second. Instead of running a long main line back to get head, they believe an artificial head will give them cheaper results. They have electric power there, and only a small No. 10 wire carries the current for the pump. The pump is a "Cameron" from Catton, Neill & Co., size 4", giving 520 gallons per minute.

Third. In the first field the lines of cane were not quite perpendicular to main line. In this way, laterals have little longer pipes than need be.

Fourth. An improvement will be the washer placed in the sprinkler head to give the correct pressure flow through the sprinkler. This is an individual adjustment for each sprinkler, and corrects for unevenness of terrain, etc. Larger size pipe can be used, giving more head through less friction and can be adjusted for each nozzle. Instead of placing an order for several sizes of small pipe, a larger order for one size pipe can be placed, thereby effecting a saving.

Fifth. A weir, or preferably a meter, should be placed at intake, so that actual water data may be obtained.

Advantages of System

(1) *Water Regulation:* Any amount of water may be given, 1 inch or 5 inches, largely depending on time turned on.

(2) *Water Saving:* 1,300,000 gallons per day for 100-acre field under old style, only 750,000 under new, but this estimate has not been checked by actual measurement. No seepage from ditches, but more evaporation.

(3) *Cultivation:* Cultivation is cheap. Unirrigated conditions. Very little hand hoeing. Secret is to get weeds when small.

(4) *Mulch Control of Moisture:* After irrigation, cultivation can be easily given, producing a soil mulch, thereby retarding evaporation and destroying young weeds at the same time.

(5) *Water Immediately After Harvesting:* It is the writer's belief that the failure of H 109 to ratoon at Hawi is largely the inability to get water immediately on the ratoons after harvesting, due to water shortage and to a shortage of labor.

(6) *Labor Saving in Cultivation (Hoeing) and in Irrigation:* This would soon pay for initial expense. For a 100-acre field, one round now costs about $14 at $1 per day. The old style would cost $120 at $1 per day. Even at $200 per acre, labor saving would soon wipe out cost.

(7) *Fire Protection:* Very apparent.

(8) *Hoeing:* Less weeds from dirty ditches, etc. Cultivation by animals under straight lines gives big labor saving.

(9) *Area Saved:* Saving in acres taken up by ditches, watercourses, etc.

(10) *Harvesting:* Harvesting simplified by straight lines. No hapa lines.

(11) *Day and Night Irrigation.*

(12) *Fertilizer:* Fertilizer action not delayed by lack of proper moisture.

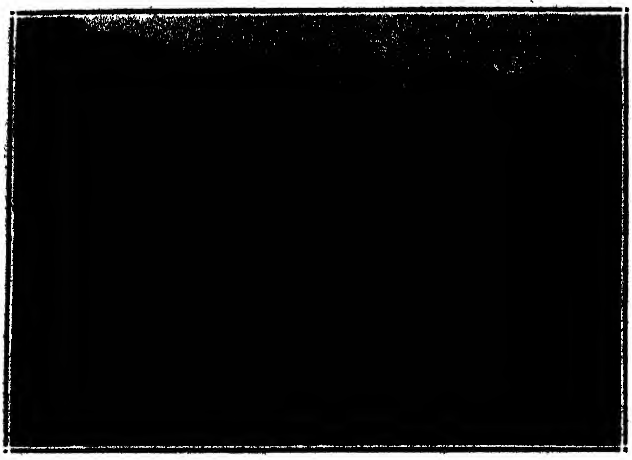
Disadvantages

(1) The cost, $150 to $200 per acre, is a big item, but same covers ten years; add interest on money to this. (See item 6 of Advantages.)

(2) Some sprinklers are slow in starting, but are easily started by lifting with a forked stick.

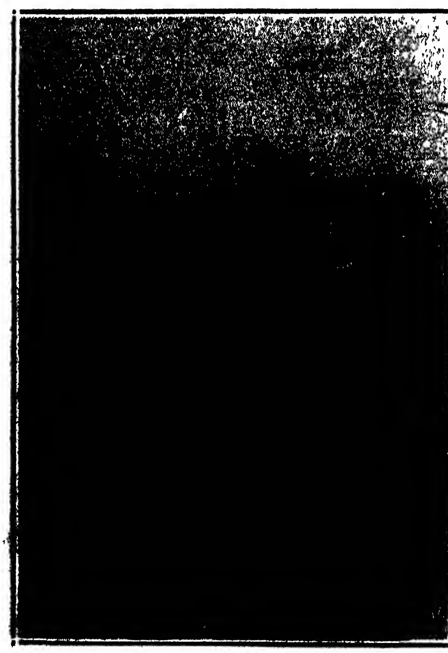
(3) Clogging later on from rust, etc., is possible, but many practical ways may be thought of to overcome this.

(4) Evaporation loss, and loss through some water not getting to the roots through trash and heavy cane, compensated somewhat by less ditch seepage losses.



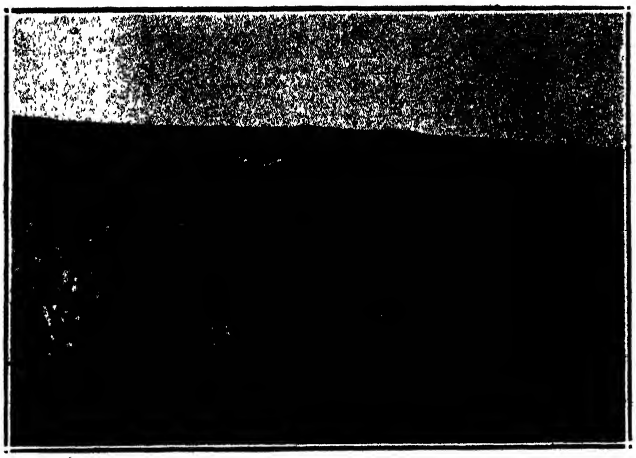
Intake of the Main Pipe line in Field Hoea 12.

This is 920 ft. from the field where overhead irrigation is used.



This water wheel runs scrapers over very fine screen.

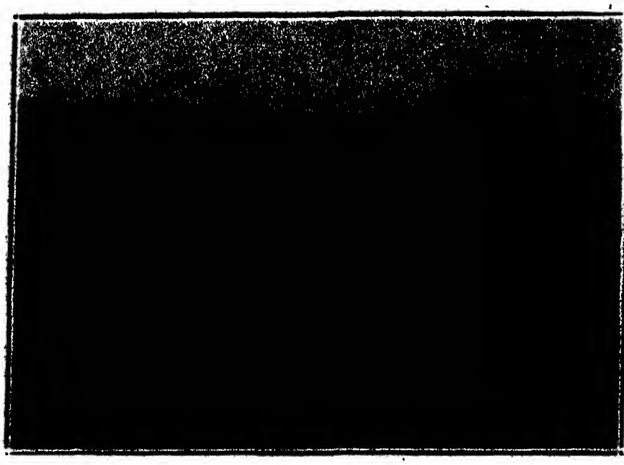
Another view of the water wheel.



Field Hoea 12, first field planted for use under the new irrigation system. The variety is D-1135 cane. Note stake bearing number of lateral line.

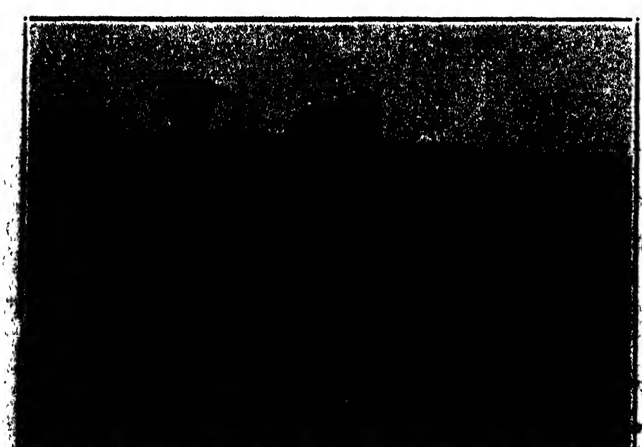
A four-inch electric pump installation.

Silt Box.
Manager Henry Hind standing in box where screen and water wheel will be. (One main pipe line can be seen running to the right, another towards the horizon.) (Note rocky condition of soil.)

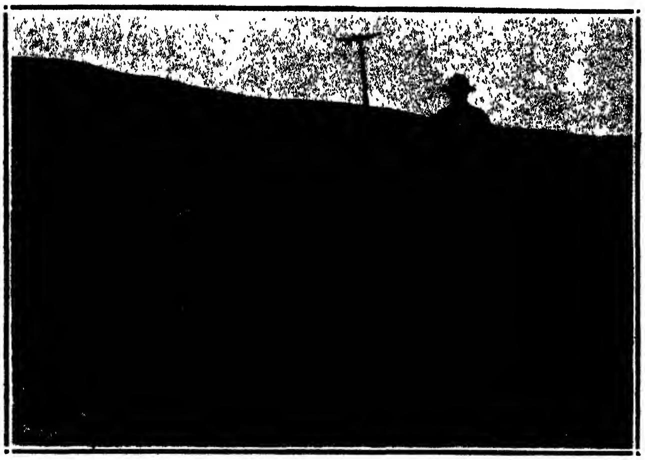


The sprinkler is cleared by lifting the upper part from the base.

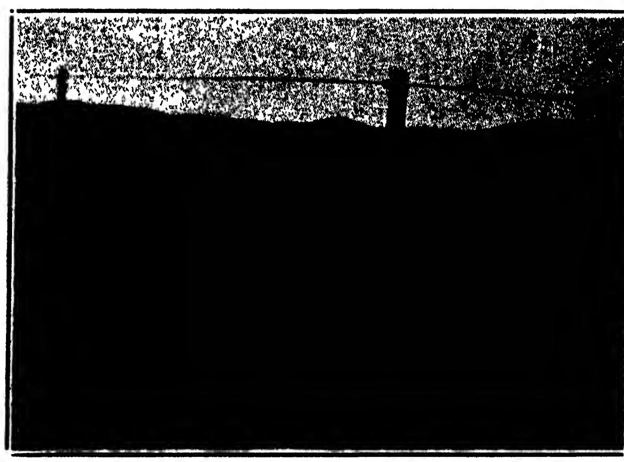
This view shows the detailed construction of the two parts of the sprinkler. Note that the standpipe is reduced from ¾" to ⅜".



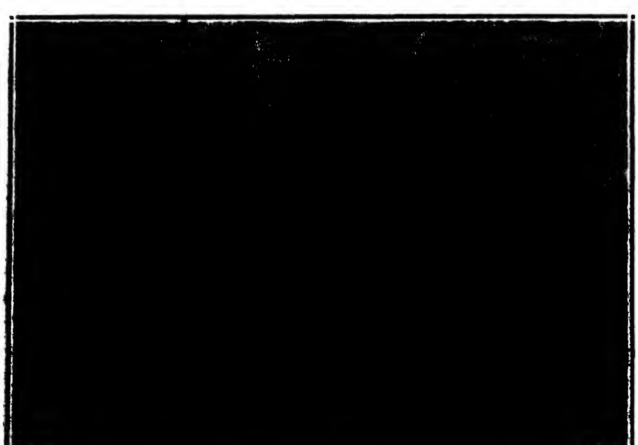
Note straight lines for cultivation. Standpipes visible on horizon to right of horse.



This picture shows pipe line running close to the cane row; the standpipe and the pressure gauge can also be seen.



Skinner overhead system by roadway where winds are stronger. This system clogs more than Hind system.



These standpipes are wired to stake as shown here. Each lateral line numbered for reference in irrigation, hoeing, etc.

The Jeswiet Identification Characters of Sugar Cane

By Twigg Smith

Dr. J. Jeswiet, of Java, has established the fact that the arrangement of the small spines or hairs on the eyes and leaves of sugar cane is never the same for any two varieties. He has classified these minute hairs into seventy or more groups.

We first became interested in Dr. Jeswiet's work in attempting to establish the parentage of the seedling grown by Mr. Richard Lyman in Kapoho, Olaa plantation. This was a seedling of H 109, but was thought by several people of the plantations and the Experiment Station to bear a marked resemblance to Yellow Caledonia. We have never been able to secure a seedling of Yellow Caledonia. Repeated efforts have failed. If this Lyman seedling had Yellow Caledonia as its male parent it would be a very important cane to use in our cane breeding work, for thereby an opportunity would be offered to use tassels from the Lyman cane to introduce Yellow Caledonia characters into our seedlings. Mr. Smith has, however, been able to establish to our satisfaction, through the Jeswiet methods, that the Lyman seedling shows the Jeswiet characters of H 146, and that that cane and not Yellow Caledonia is in all probability its male parent.

This information results in saving time and expense that might otherwise have been given in breeding from the Lyman seedling in the hope and belief that it might be of Caledonia parentage. Another illustration of how this work is of commercial benefit to the industry is described as follows:

The best cane for mauka lands, among our established varieties, is Yellow Tip. This cane, unfortunately, is extremely susceptible to mosaic disease and is so sensitive to it, once the disease is contracted, that the yields are reduced to such an extent that profitable crops are hardly possible. D 1135, on the other hand, is extremely resistant to mosaic disease.

We have grown hundreds of seedlings, taking tassels from Yellow Tip, in localities where there were prospects of obtaining crosses with D 1135. Out of 800 such seedlings at the Manoa substation, 200 have been selected for preliminary plantation try-outs on Kauai and Hawaii. This work will be greatly facilitated if we can establish to what extent we have succeeded in actually obtaining crosses between Yellow Tip and D 1135.

Mr. Smith, in examining some of the seedlings, finds unmistakable evidence of D 1135 characters in these Yellow Tip seedlings. There are reasonable prospects that among such crosses we will find varieties which maintain the vegetative vigor and weed-suppressing qualities of Yellow Tip combined with the mosaic disease resistance of D 1135.

Still another instance of the possible benefit from this work will be in establishing definite identifications of the scores of seedling canes which are about to assume commercial significance on the plantations.

The present article deals with the study of ascertaining the parentage of the Lyman seedling.—H. P. A.

As an introduction to the work of establishing the identity of our sugar cane varieties in general, and of determining, where possible, the parentage of seedling

varieties I have taken passages from the published articles* of Dr. J. Jeswiet. This abstract of his work follows:

From the moment that in Java the importance of cane selection was realized, a want was felt for a proper manner of description by which the varieties might be recognized. Without such a description, it is natural that in the culture of many varieties of cane, confusion may cause great losses of time and money as by mixing an early ripening variety with a late ripening one, or the mixing of canes of low and high sucrose content. Also it has ofton happened that a once condemned variety has reappeared under another name. The same applies to the importation of foreign varieties for which we have no guarantee as to genuineness of character. Therefore reliable descriptions are of great value to check importations as well as to establish our own varieties, giving us an insight into their relation and their origin. It is also of great use in judging the seed consistency of the types obtained from repeated self-foundation.

Method of Description

The stalks of cane can be separated into two groups: Flowering and non-flowering.

The differences manifest themselves towards the flowering period, when the stalks that will flower begin to show changes in the tops. The upper leaf sheath becomes very long and the leaf blades keep getting shorter. The upper internodes which carry the flowers are longer and the eyes are absent.

The non-flowering stalks always become longer than the flowering ones and towards the finish of their growing period form the so-called "top bibit" or seed cane, a series of short joints with strongly developed eyes and root eyes.

I have based my method exclusively on non-flowering stalks. This method, then, is applicable on non-flowering crop cane on top bibit (seed cane) and on the plant cane from 4 to 6 months old, both with the leaf top on. Plant cane below that age also checks, but the hairing on the leaf sheath especially may fail at times. With older cane the hairing on leaf sheath is a safe and reliable characteristic.

Besides the characteristics which indicate the variety we must look for smaller Bertillion marks which indicate the individual within the group. These characteristics must be constant as much as possible and little dependent on exterior influences. Important from a morphological standpoint, they may have little value physiologically.

I believe these characteristics to have been found in the hairing of the eye scale, the leaf sheath and the blade. These groups have proven sufficiently constant and can be used for the description of individuals from the type Saccharum officinarium, as well as in the systematic system of the botanical types of the genus saccharum.

While the shape of the eye may alter in cane of different ages or environment, the hairing suffers least in variation.

Other Characteristics That May Be Used in Determining the Variety

Fairly Good Characteristics

Cork Cracks. Fine cracks in ground tissue which later dry up, leaving marks.

Growth Cracks. Deep cracks running with the stalk sometimes into root ring. Sometimes called wind cracks.

Minor Characteristics

Length and Thickness of Cane. These are greatly influenced by outside conditions, such as poor soil and irrigation.

Color. Is very changeable according to exposure. Never can the stalk color be taken as a basis for classification.

Wax layer. Varies for different locations.

Shape of the Joints. Also may be changed by different causes, such as drought, temporary stagnation or stripe disease.*

* From the "Description of Cane Sugar Varieties, Part 1, Morphology of Sugar Cane," by Dr. J. Jeswiet, Chief of Division on Cane Improvement at Pasoeroean. Archief, XXIV, Part 1, 1916.

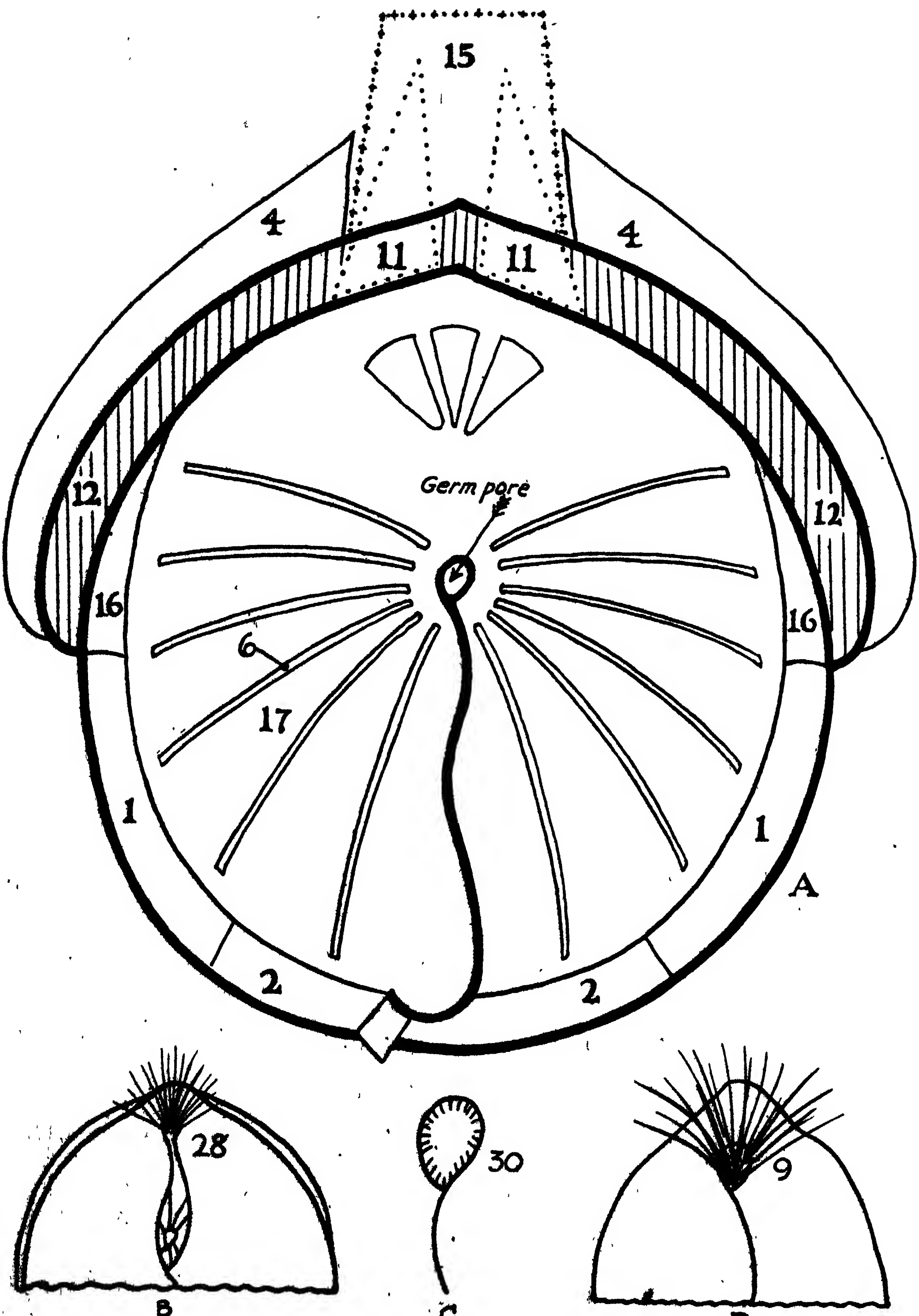


Fig. 1. A. Plan of outside of round type of eye, with central germ pore, radial veins, wings attached about center, and a part of the hairgroups by numbers occurring on that side. B, C and D, groups occurring on germ pore.

Circumference. Length and position of the joints very variable.

Eye Groove. Sometimes present, often absent in same variety and same stalk.

Growth Ring. The zone separating the root ring from the joint, color changeable, but shape and general appearance a useful auxiliary characteristic.

Root Ring. Shape and location reliable.

Root Eyes. The number of rows of root eyes is of great value in classification of the botanical variety.

THE EYE

There are two main shapes of eyes, round, Fig. 1, and oblong, Fig. 2. In round eyes the wings are attached above center, in oblong below. The place of attachment is called the wing corner. Round eyes have a more or less central germ pore, oblong eyes an apical germ pore. By germ pore is meant the opening developed by the swelling of the eye through which the young shoot emerges. The scale nerves or veins lead to the germ pore, causing a great difference in appearance between the round and long eyes.

Between these two types of eyes all kinds of transitions exist, but the hairing of the eye remains comparatively constant. The position of the eye in relation to the stalk can be quite different in different varieties. It may be growing in a deep cavity, pressed close against the stalk, or standing clear away from the stalk.

All cane eyes are more or less haired. The kind of hair is very different for the different varieties and is to be found in always reproduced groups making it possible to recognize the different cane varieties. It is clear that both presence and absence of the groups are to be considered. The appearance, extent, as well as the length of the hairs is subject to variation, but in a small number of sticks taken at random an entirely sufficient number of eyes can be found which correspond with the typical hairing.

To facilitate recognition all the hair groups have been given a number as shown in Figs. 1, 2 and 3.

Following is a description of the groups with their specific numbers:

FRONT VIEW OF THE EYE

1. Fairly long white hairs on both sides of the eye scale below the connection of the wing; common; of variable extent.

2. Fairly short white hairs, at times interrupted by groups of long hairs, alternating with scale veins, sometimes a strong group of long hairs covering up the short ones; common.

3. White, more or less long, covering up group 12.

4. Long white hairs, sometimes just at base, at times over entire edge, again, leaving top free.

5. White, generally long, mostly in varieties with long stretched eyes as H-146, strongly pressed together, waxed or straight haired group at top of or in between veins, sometimes only on one side.

6. Short brown or black hairs between the veins, similar to growth between veins on leaf sheath; common.

7. Short brown, at times long and white. Nearly exclusive with round eyes, or where there is room above germ pore, not always one definite group, sometimes detached groups.

8. Long white hairs, starting above the wing corners extending nearly to top, leaving top free, growing on junction of wing and scale (extent shown a little short in illustration to make room for groups No. 12-13).

9. Long hairs showing in the germ pore growing on the surface of second scale, very rare.

11. Long white hairs on the edge of wing and blade, or on the wing just below the wing top, generally pressed against the wing, sometimes extending beyond it, mostly waxed.

[* Dr. C. A. Barber in the Memoirs of the Department of Agriculture of India (p. 146, Vol. 8, 1916) says: "The question of striping is always of interest. One would expect in seedlings of a striped cane a larger proportion of cases with striping in the stem. This does not appear to be the case. The striping breaks down completely in the seedlings—when it occurs it is seen in striping of some of the younger leaves. The color of the parent has some little influence, although comparatively little on the color of the seedlings derived from it, the proportion of green being most uniform."] T. S.

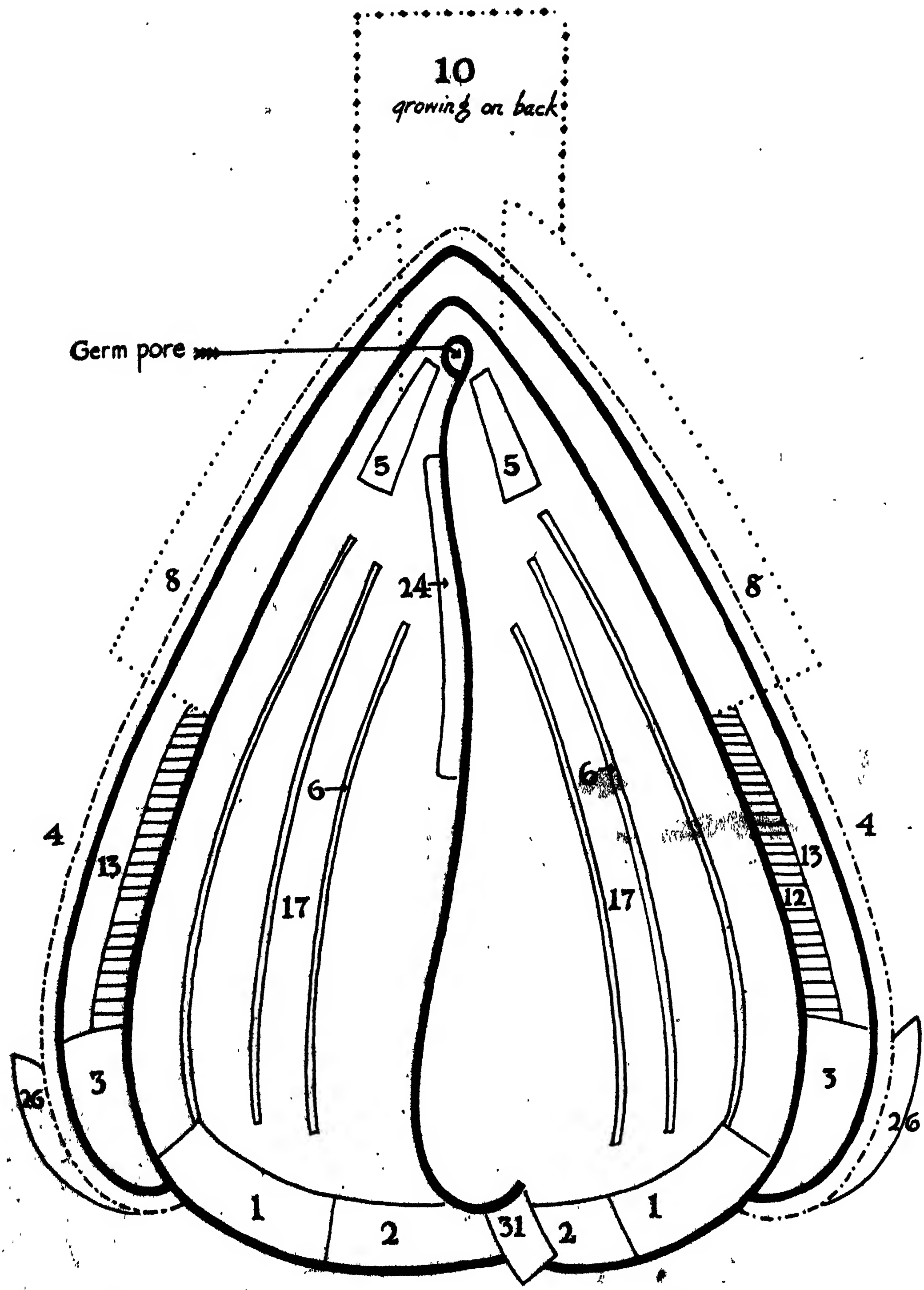


Fig. 2. Plan of outside of oblong type of eye with apical germ pore, veins convergent towards the top, low attached wings and a part of the hairgroups, by numbers, occurring on that side.

12. Adjacent small black hairs, sometimes extending all over wing or only on parts. Primitive and present in all varieties.

13. Long adjacent white hairs, on wing surface, sometimes over entire surface, at times envelop group 11. When group stops, group 12 appears again. Rare.

15. Long white on top of scale at times short and dark. Sometimes occurs by itself as a group, at others a continuation of No. 4.

16. Long white hairs, surface of scale close to wing border line above lateral group 1.

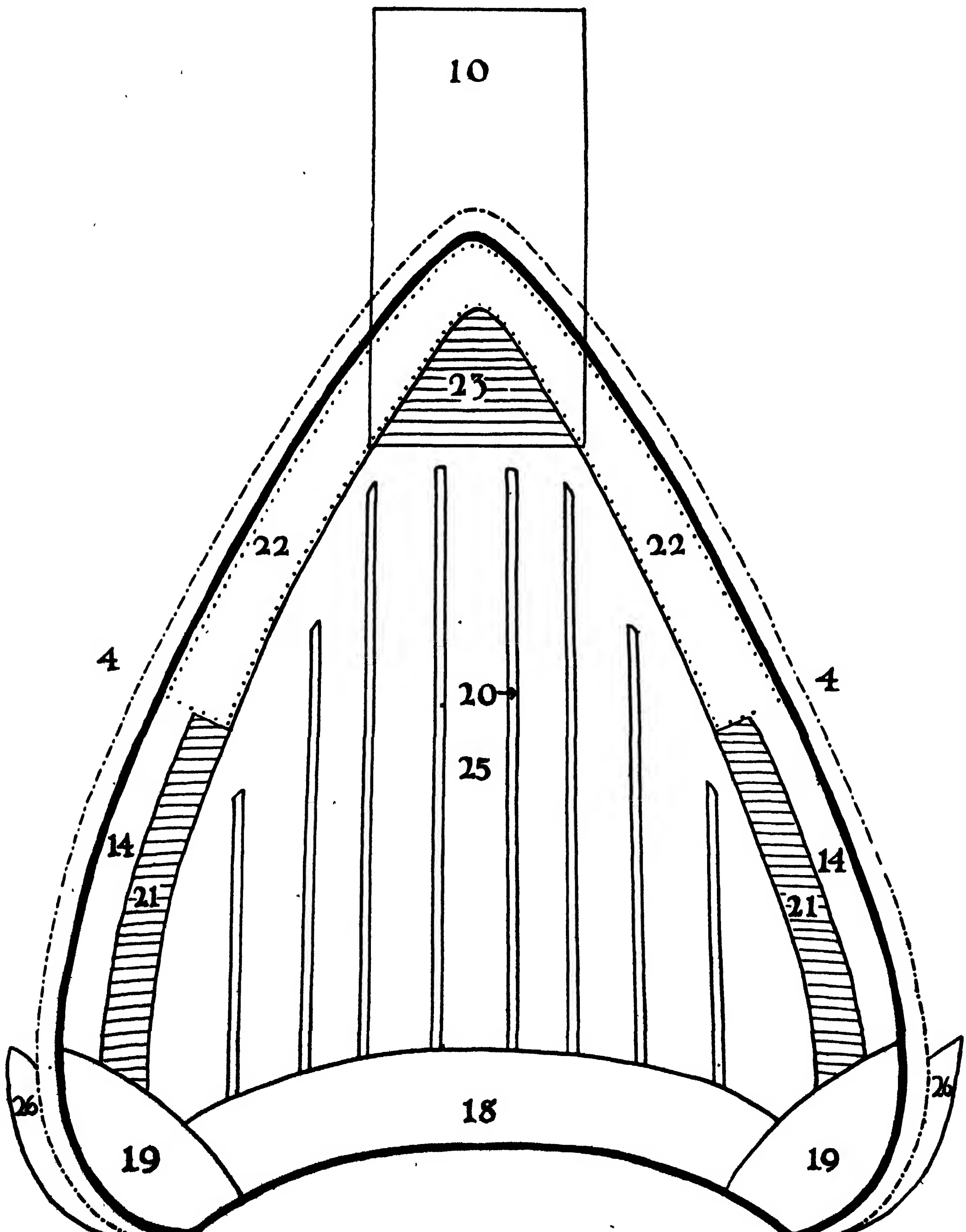


Fig. 3. Plan of back of oblong eye showing, by numbers, part of the hairgroups occurring on that side.

17. Long white hairs lying close together between scale nerves, sometimes mixed in with No. 6.

24. Short white or brownish hairs on top or overlapping edge of scale, generally on upper half, very characteristic.

28. Long white, seen through extended germ pore growing on second scale.

30. Short brown, on edge of germ pore.

31. Long white, at base of overlapping edge, generally pointed down.

Back View of the Eye

10. Long white, generally on the scale between veins but may extend on the wings, varies greatly in number of hairs, often of two parts. When extending on the wings often absorbs wing groups equal to 11 on the front.

14. Long white, similar to No. 13, but on the back—seldom seen in Saccharum officinarium, characteristic for the wild grown varieties.

18. More or less long white hairs on basal edge at back, sometimes only in center, at others clear across, may be a solid line or alternate with the nerves.

19. Long white hairs, sometimes confined to the corner, at others extending towards the center.

20. Scattered short brown hairs between nerves.

21. Short brown hairs, may extend all over the wing. Common.

22. Long white hairs, a narrow ribbon on edge of wing and scale, often a connection between 19 and 10.

23. Short brown hairs on top of scale, connects with short hairing of 21, sometimes covered by 10.

25. Long white between nerves, a silky appearance.

26. Long white in wing corners.

29. Long white only on very wide eyes.

The Sheath and Leaf Blade

Color, waxing, size and position vary too much to be of special use. The shape and hairing of the ligule are an especially good characteristic for the botanical varieties. The joint triangles, the zone right behind the ligule vary considerably in shape and hairing for the different varieties; sometimes they are absent.

The hairing of the sheath and leaf, however, is constant and is of great value in determining the variety. See Figs. 4 and 5.

Outside

Group 51. Soft, silklike, white, long, extending beyond leaf edge growing behind the ligule on the joint triangle, never reaching the midrib, but reaching up to leaf edge, longest at leaf edge, growing smaller towards midrib. Present in all varieties of Saccharum officinarium.

Group 52. Short feltlike white hairs, between nerves on joint triangles (not a very significant group).

Group 53. Long silklike lashes on lower part of leaf edge above joint triangles, often continued up leaf, at times broken off, leaving sharp hooks on edge of leaf, both sides.

Group 54. White hairs on the upper edge auricles, varying length.

Group 56. Long white on edge of upper part of overlapping leaf sheath, *rare.*

Group 57. Long white hairs in center. Very important, changes in extent, may start high or low, narrow or wide, etc. Length of hairs, position and quality variable. See H-109, Lahaina, H-146, etc. Sometimes missing entirely.

Group 59. A ring of hairs on leaf scar, in nearly all varieties in young suckers. Fairly rare in mature cane.

Group 60. Long white lateral groups, rare, a ~~narrow, thinly~~ growing group, example H-109.

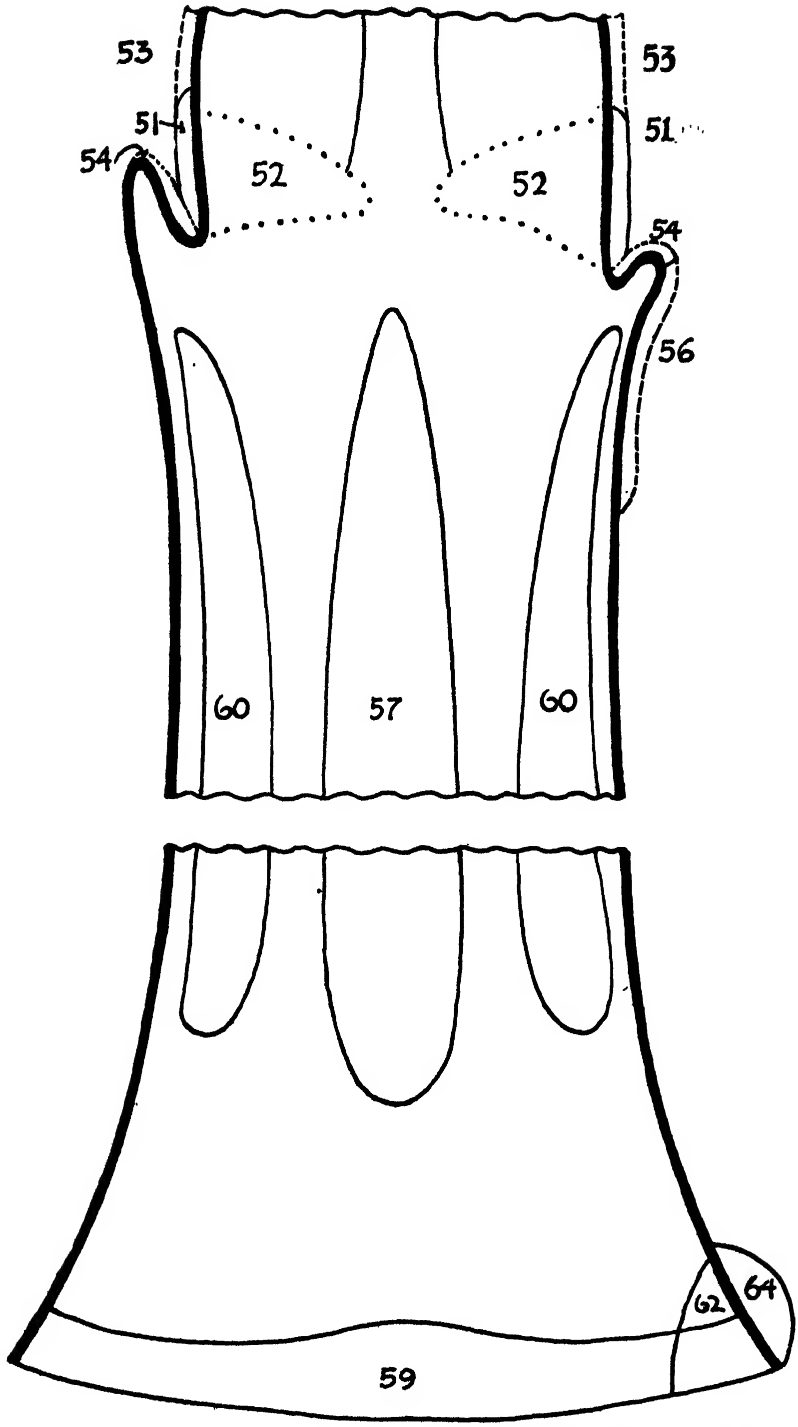


Fig. 4. Plan of sheath and juncture of sheath and blade of the leaf with hairgroups by numbers, seen from outside.

Group 62. Silky, long, white hairs at base, fairly frequent.
Group 64. Long hair on base of upper flap of sheath, fairly rare.
Group 67. Velvet hairing on leaf surface, rare (not shown).

Inside

Group 55. Generally fairly long white, sometimes extends up midrib. Grows on midrib behind ligule, rare.

Group 58. Very short, feltlike, white hairs on joint triangle, group characteristic, generally hidden by wax.

Group 61. Short hairs on edge of ligule, common, generally short.

Group 63. Very short tough hairs, triangular group on midrib behind ligule, varies in length.

Group 65. Single row of hairs growing behind but not projecting above ligule, extending its full length (not shown in drawing), rare.

Group 66. Half free thick hairs on back of ligule (not shown).
Group 68. A double group behind ligule.
Group 69. At base of leaf sheath on the under side.
Group 70. Long soft hairing on long auricle. Fig. 5.
Group 71. Soft white hair on small auricle. Fig. 5.

In order to become familiar with the method used by Dr. Jeswiet I have examined and made drawings of several varieties of our canes. I have found that the hairing of the eyes, leaf sheath, and leaf does appear regularly in the same positions regardless of where the cane is grown.

A Comparison of the Lyman Seedling With H 146 and H 109

As a practical example I have been able to establish the identity of the so-called Lyman seedling, the parentage of which was doubtful. It was said to be a seedling of H 109 and Yellow Caledonia.

The one stool I examined is similar in general appearance to H 109. It differs in growth, whereas H 109 has a tendency to increase in circumference of internodes towards the top, the seedling decreases; also the internodes of the seedling are somewhat larger and barrel-shaped, and very much softer.

From the plan in Fig. 6 it will be seen that the pollinated tassels of H 109 were taken in the vicinity of other canes; therefore it was logical to examine them. This was done and the similarity in the eye, leaf sheath, and leaf of the seedling and of H 146 was immediately evident. They are identical in the ligular process, and the hairing on the scale of the eye occurs in the same places, and their germ pores are the same, bursting being central in both cases. Their wings are the same, being attached in the same manner, and their veining is the same, towards the central germ pore.

With H 109 the seedling has few things in common. A first glance shows the general shape to be the same, but there are marked differences everywhere else.

H 109 has an apical germ pore with veins running longitudinally to it. Its edge is nearly always very irregularly shaped and hooked. Their wings are attached very differently. The hairing of the scale of the eyes is very different and there is no similarity in the ligular process or on the back of the leaf sheath.

These comparisons would place the Lyman seedling as a progeny of H 109 with a marked tendency towards its undoubted male parent, H 146.

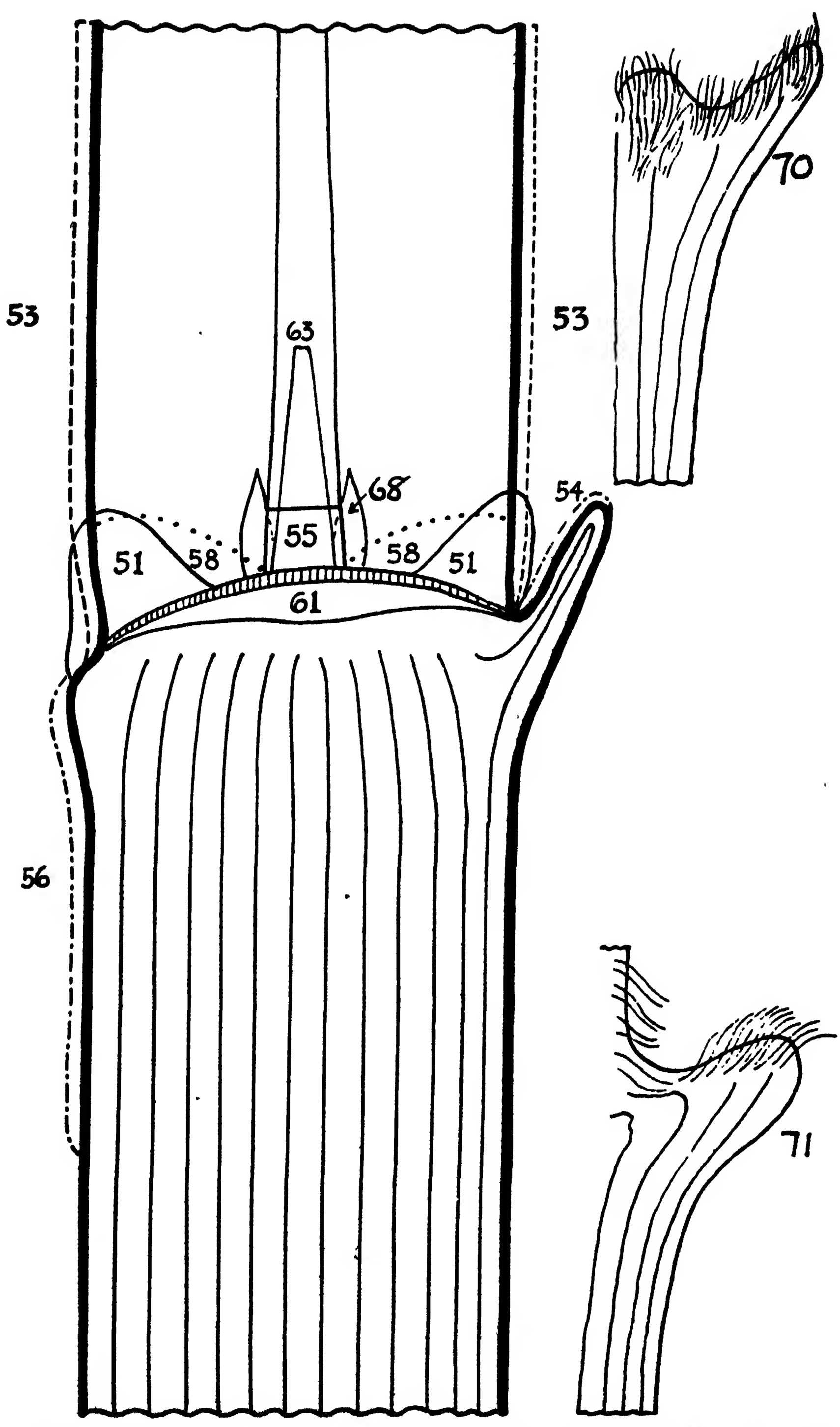


Fig. 5. Plan of sheath and juncture of sheath and blade of the leaf, with hairgroups by numbers, seen from within; also hairgroups 70 and 71 which occur on outside of auricles as shown.

A Comparison of Yellow Caledonia With the Lyman Seedling

Some of the points of dissimilarity between the variety Yellow Caledonia and the Lyman Seedling are found in the appearance, shape and hairing of the eye, the leaf sheath and the ligular process.

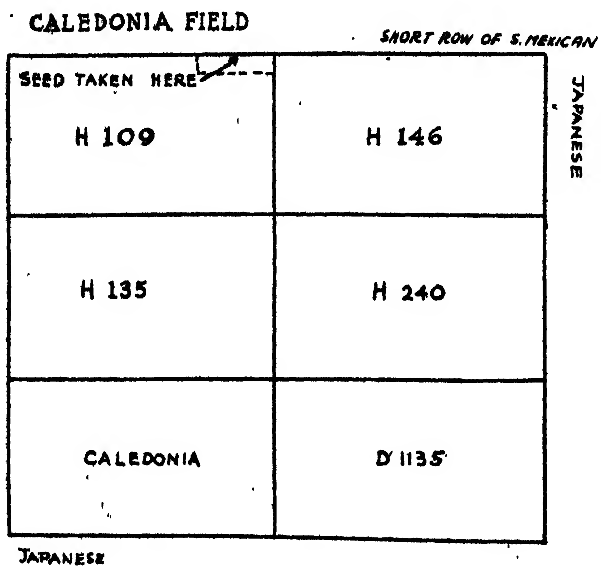


Fig. 6. Plan showing where seed for the Lyman seedling was gathered.

The Eye

First. General appearance of mature eyes.

Second. The total absence in Yellow Caledonia of groups which are prominent in the Lyman seedling and also prominent in H 146. See groups 17, 28, 30, 25, 24.

Third. The presence of groups 13 and 14 in Yellow Caledonia against their absence in the Lyman seedling.

Fourth. The marked differences in groups 11, 2, 10, 18, 19, 4, 5, 15 and 6.

Fifth. Different position of germ pore and method of bursting; also the veining.

Sixth. Wing shape and attachment.

The Leaf Sheath

First. Marked difference in group on back No. 57.

Second. Absence of group 55 on Yellow Caledonia.

Third. Also absence of auricles on Yellow Caledonia.

Lyman Seedling

General Description of Appearance and Growth

Thick stalks, barrel-shaped joints, fair-stooling, joints show tendency to get smaller as stalk grows.

Stalk fairly straight, slightly zigzag, some acari, rind very soft, one stalk broken off a foot from the ground by its own weight. Deep growth cracks.

Some cork cracks.

No eye groove.

Heavy waxing.

Six to seven rows of eyes on root ring.

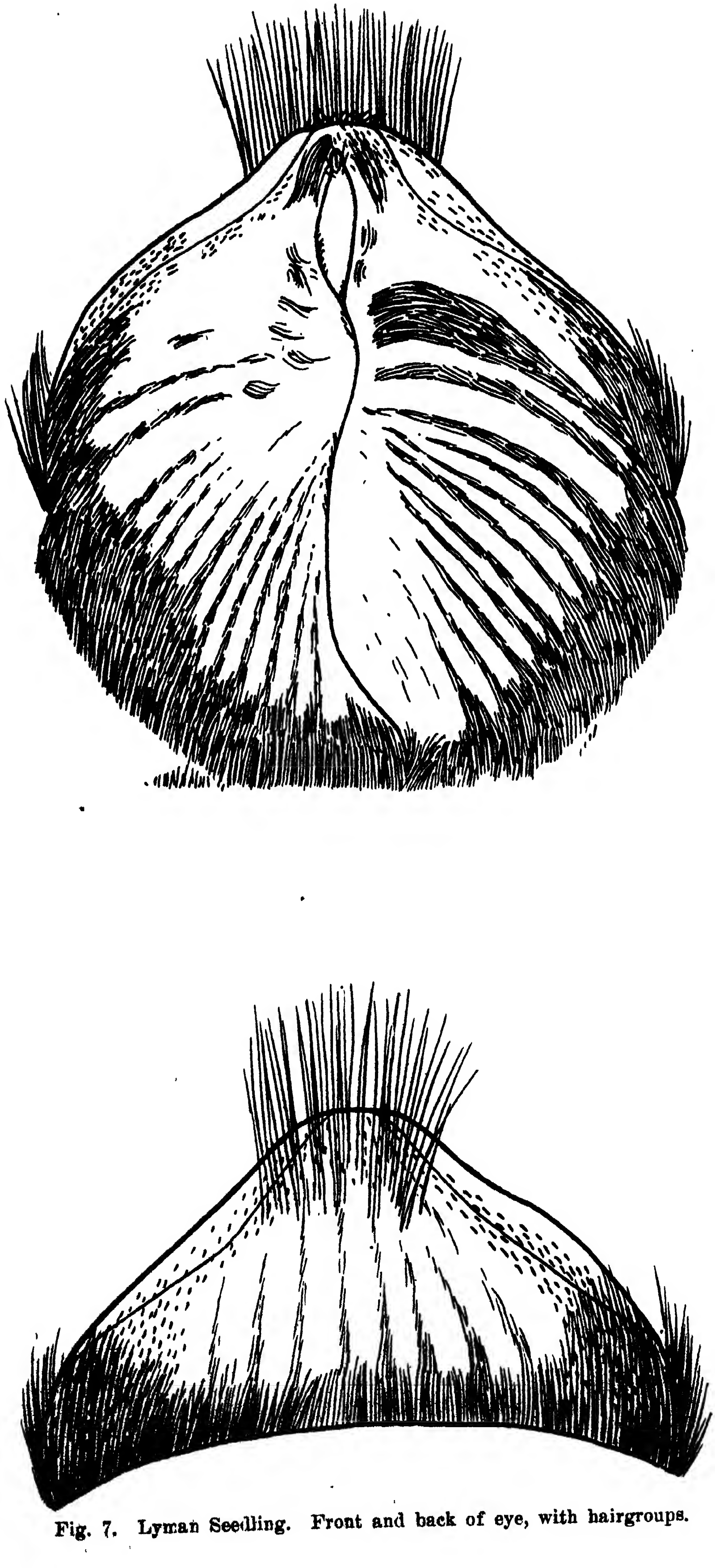


Fig. 7. Lyman Seedling. Front and back of eye, with hairgroups.

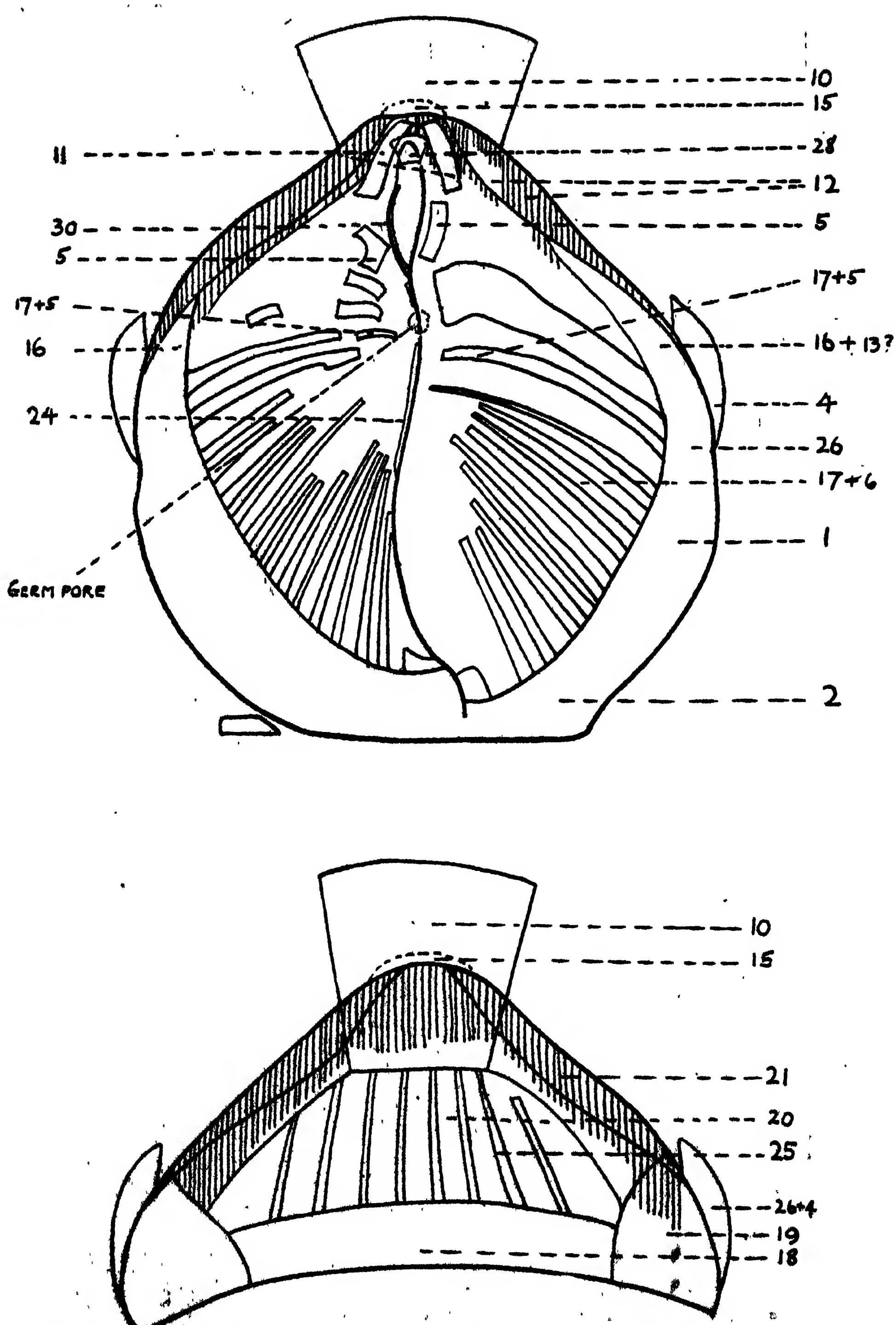
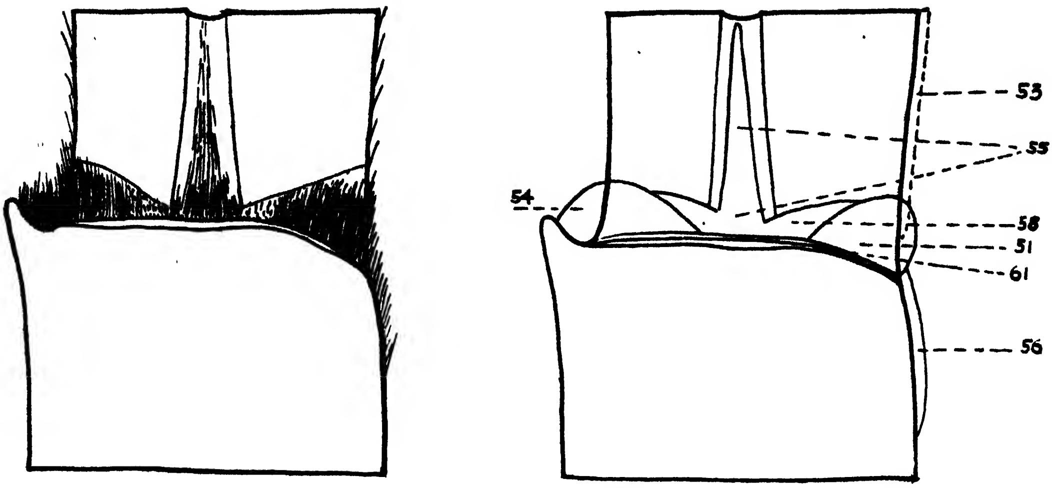


Fig. 8. Lyman Seedling. Plan of front and back of eye with hairgroups by numbers.



A. Lyman Seedling. Juncture of sheath and blade of the leaf, seen from within, with plan showing hairgroups by numbers.

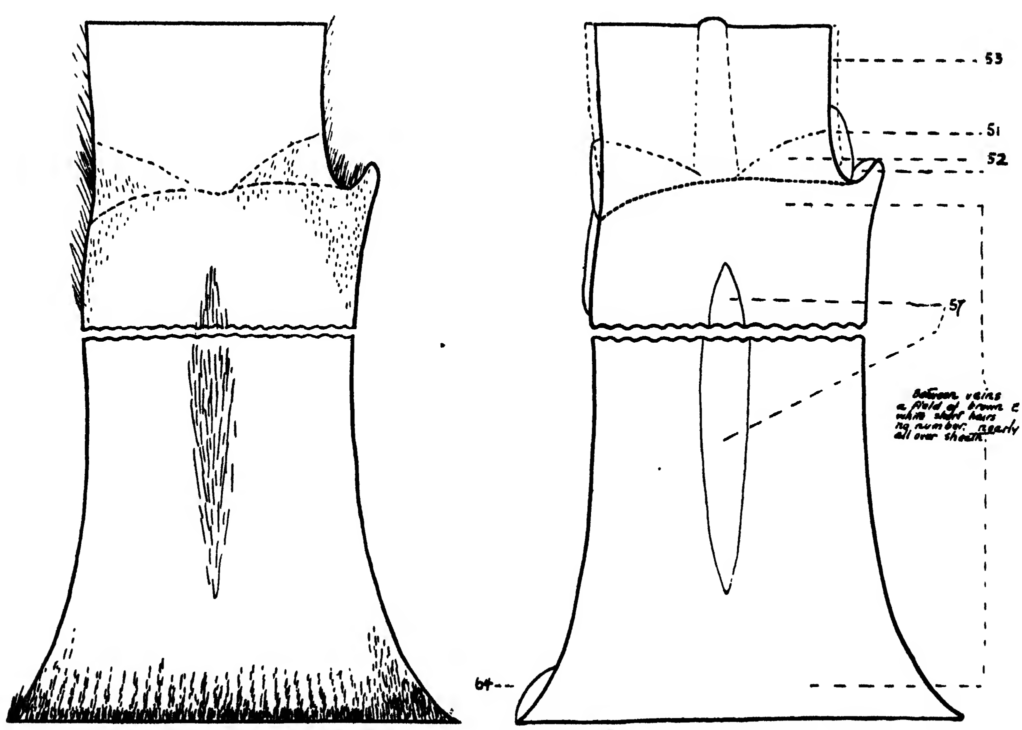
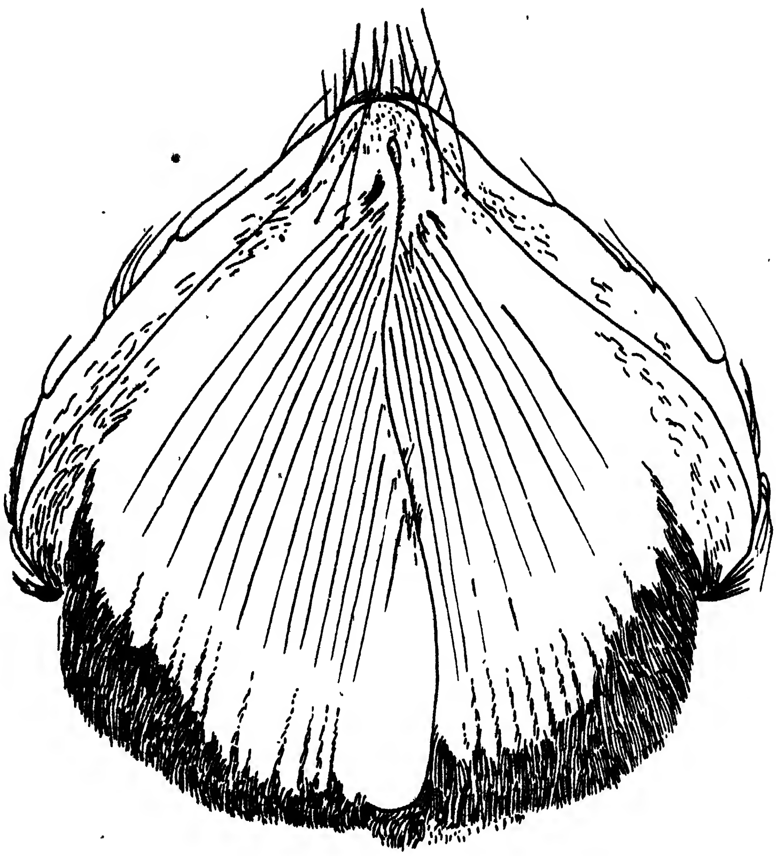


Fig. 9. B. Lyman Seedling. Sheath and junctüre of sheath and blade of the leaf, seen from without, with plan showing hairgroups by numbers.

Purplish color mostly, some dark greenish, leaf sheath attached level with node. Eye attached broadly, grows close to leaf sheath scar, wide oval, pointed, slightly flattened tip. Small wings vanishing at top.

Veined to central germ pore.

Fairly flat when young, distinctly humped at maturity, when tip turns up slightly, large in size, edge smooth.



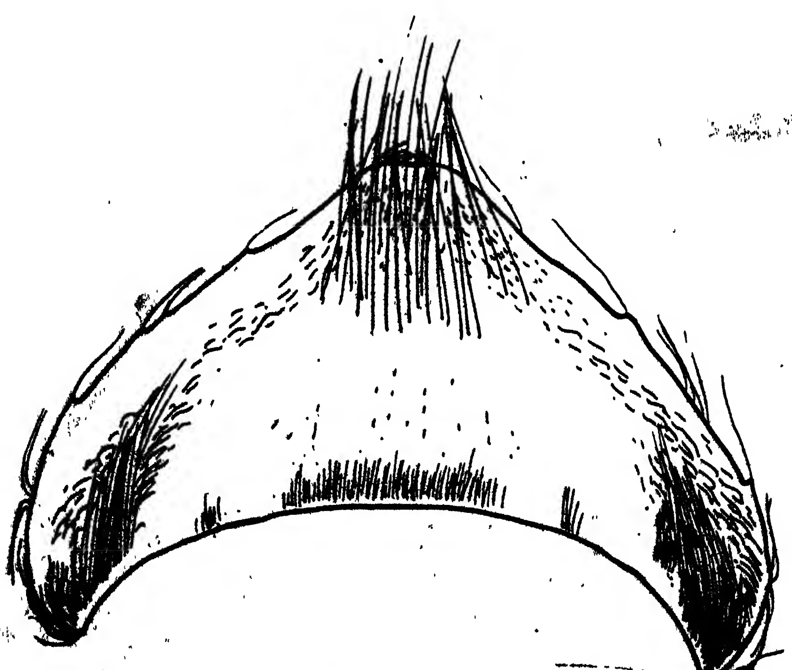


Fig. 10. H 109. Front and back of the eye.

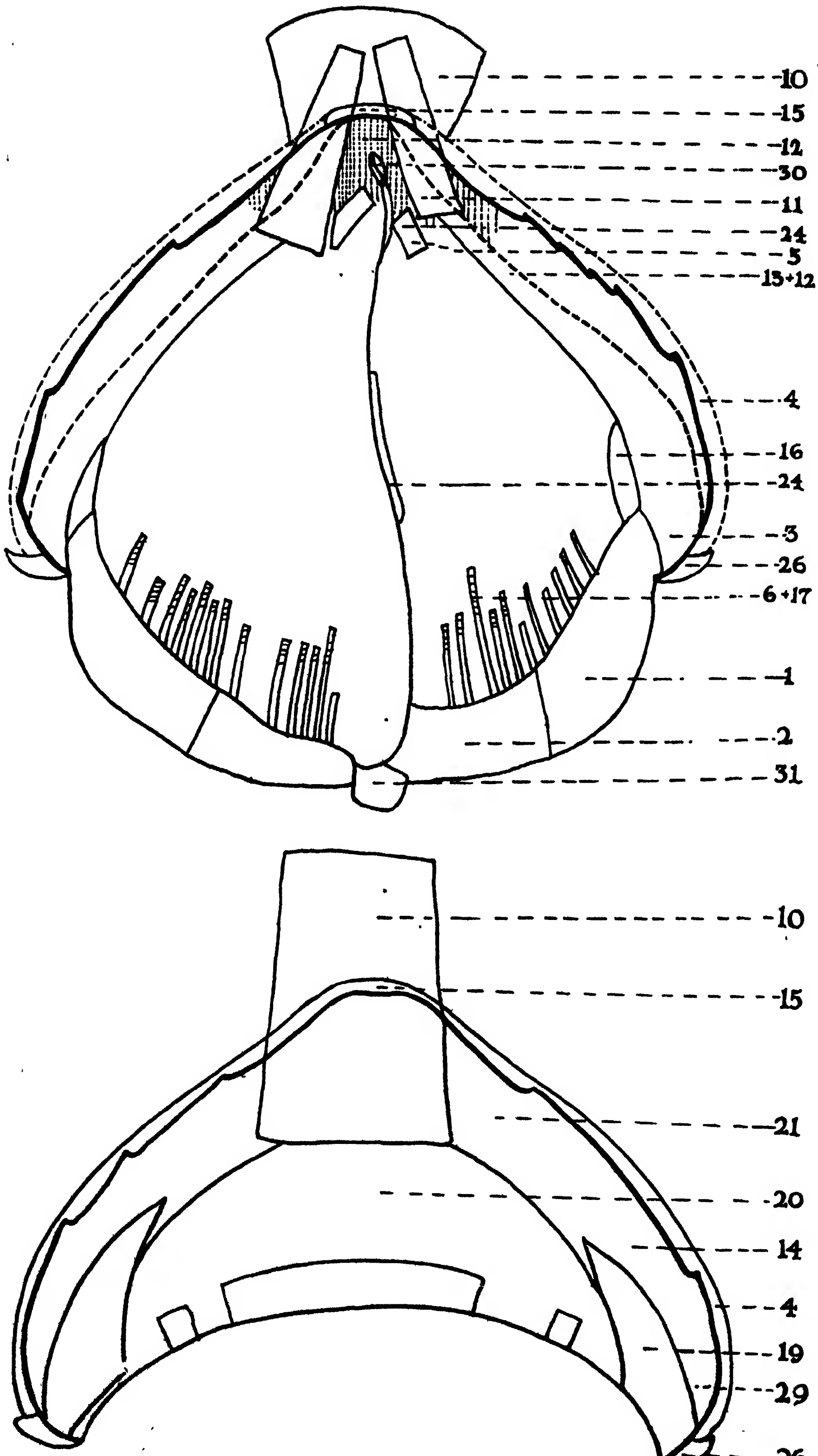
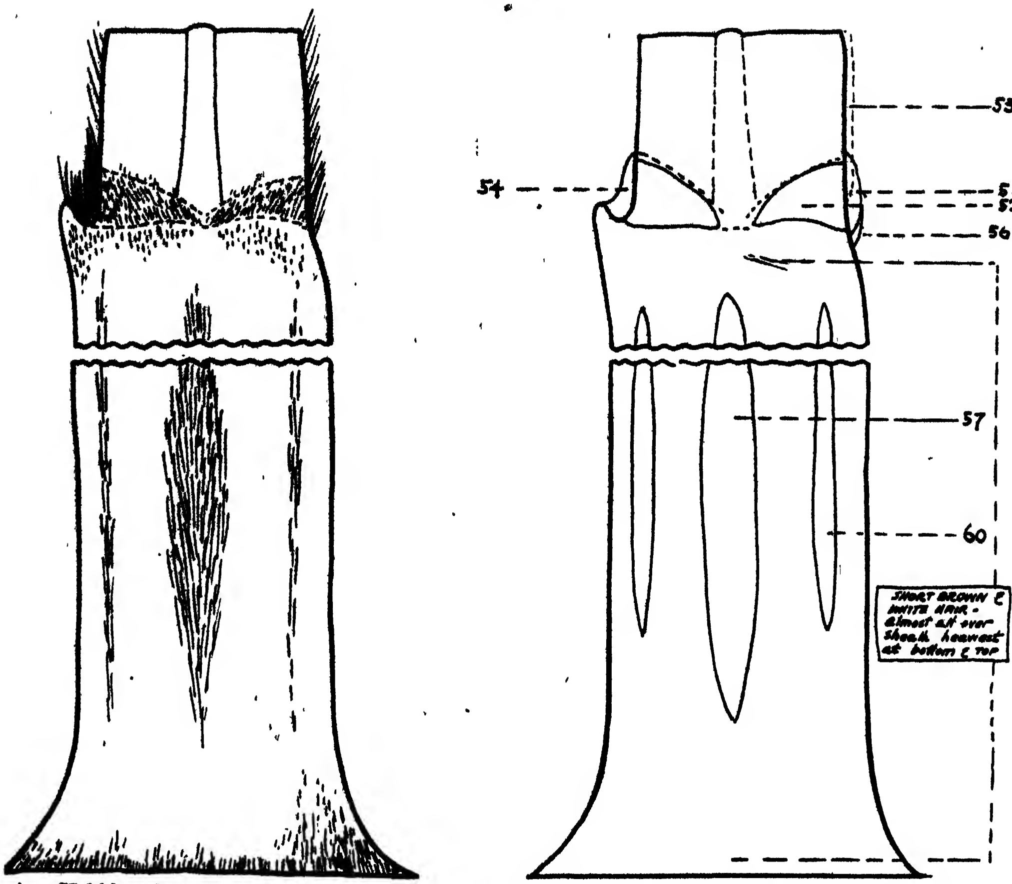


Fig. 11. H 109. Plan of front and back of the eye, with hairgroups by numbers.



A. H 109. Sheath and juncture of sheath and blade of the leaf, with plan showing hairgroups by numbers, seen from without.

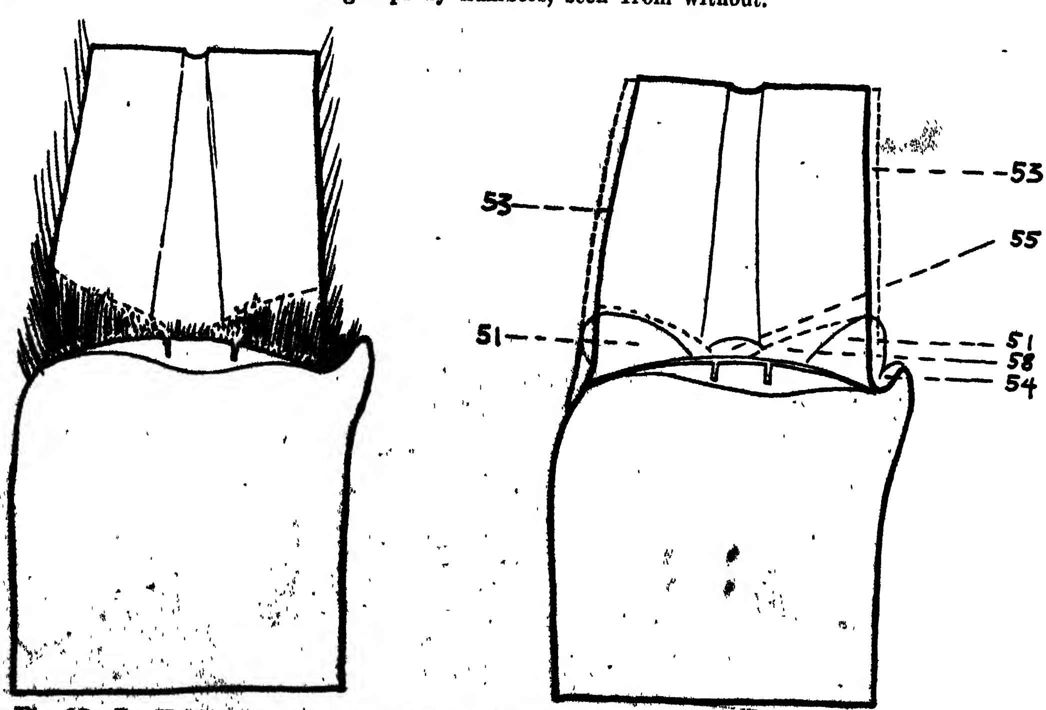


Fig. 12. B. H 109. Juncture of sheath and blade of the leaf with plan showing hairgroups by numbers, seen from within.

H 109

General Description of Appearance and Growth

Large stalks, joints generally long, somewhat barrel-shaped, though generally cylindrical, increasing in size as cane matures, grows fairly straight, slightly zigzag, rind very hard.

Some cork cracks.

Very little signs of eye groove.

Heavy waxing.

Four root eyes average.

Green at times, mostly purplish, leaf sheath attached level with node.

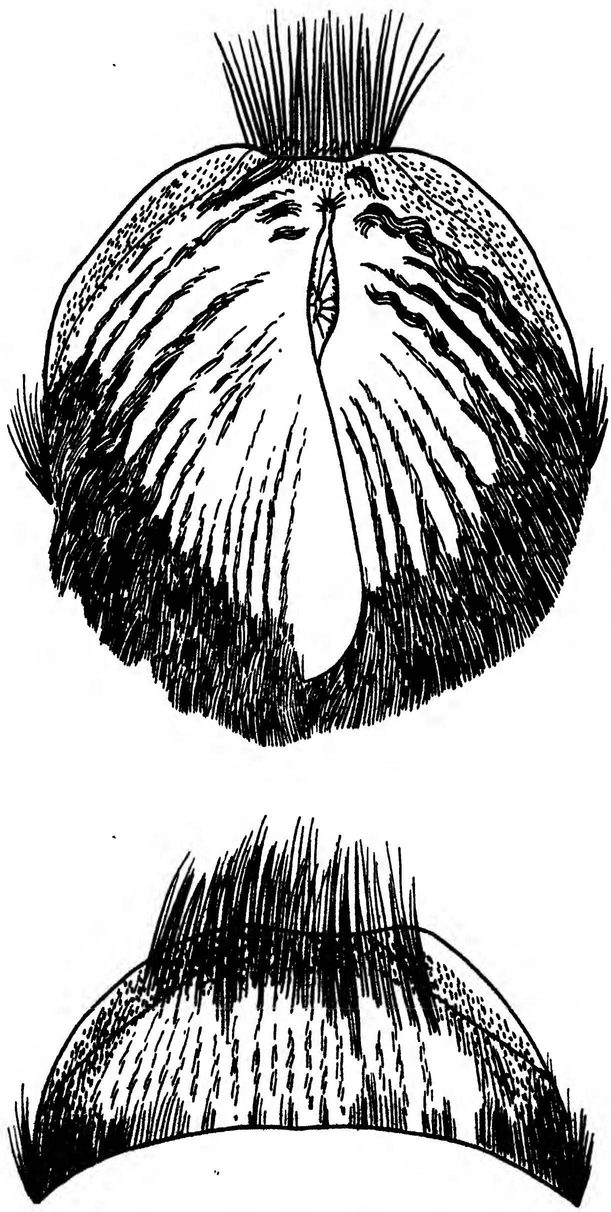


Fig. 13. Front and back of the eye.

Eyes

Eye attached broadly; grows close to leaf sheath scar; elongated when young; at maturity, rounded with pointed tip. Wings start low and go all around eye. Germ pore apical, veined longitudinally. Flat when young, somewhat humped at maturity; fairly large in size, with a notched edge as a marked characteristic.

H 146

General Description of Appearance and Growth

Fairly thick, scanty stooling, gave promise ten years ago but did not stool and ratoon well enough to make it acceptable as a commercial variety.

Grows fairly straight, slightly zigzag, very susceptible to acari, rind hard.

Yellowish, somewhat green, older a little purplish, some cork cracks, no eye groove, medium wax layer, distinct wax ring.

Leaf sheath attached level with the node.

Root ring with 5-4 eye rows.

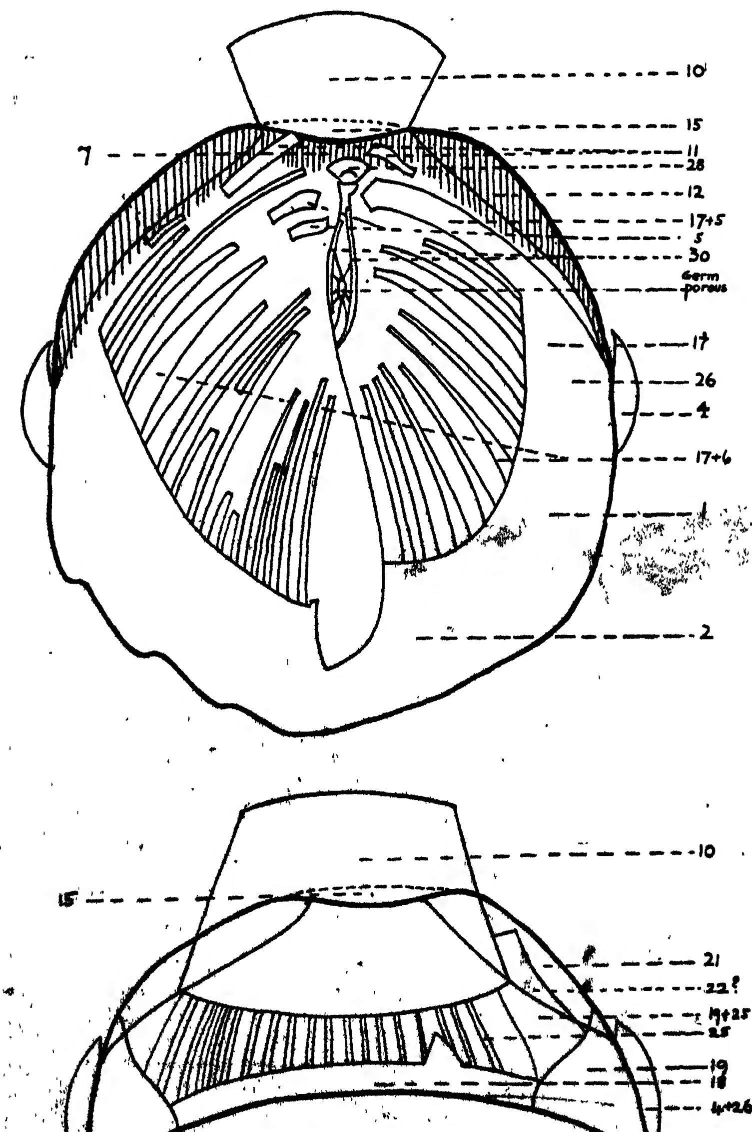
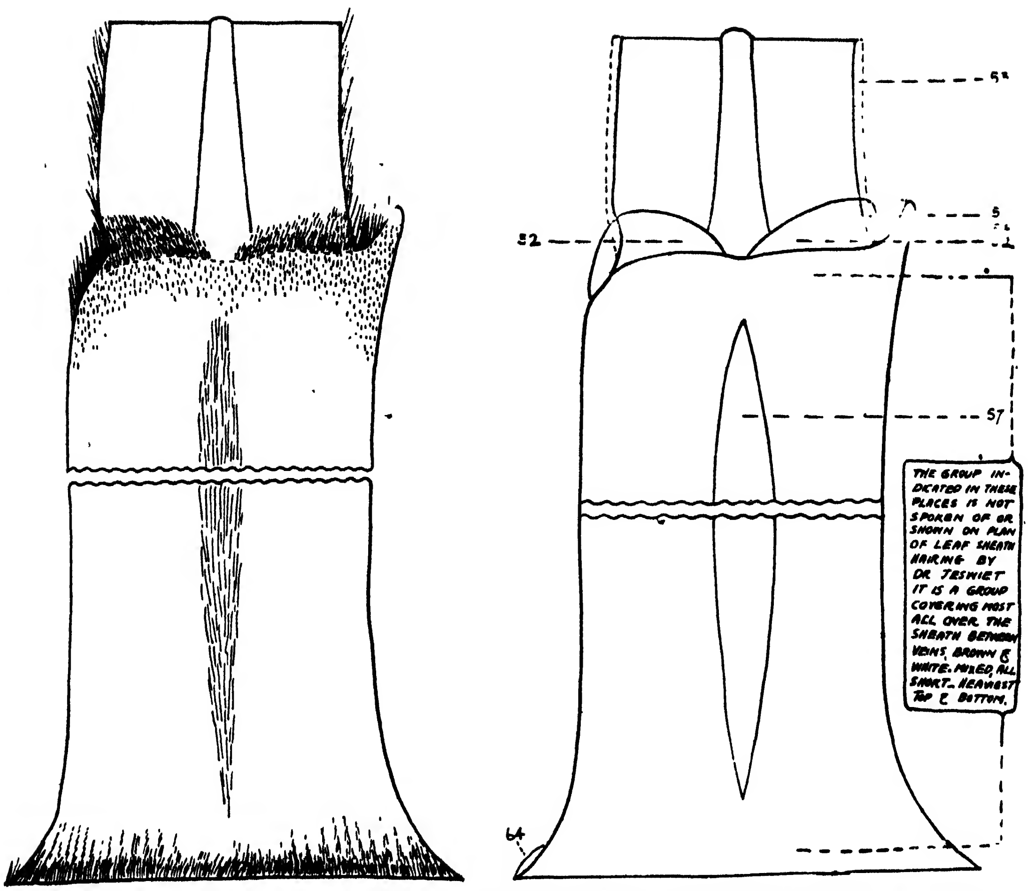


Fig. 14. H 146. Plan of front and back of the eye with hairgroups by numbers.



A. H 146. Sheath and juncture of sheath and blade of the leaf with plan showing hairgroups by numbers. Seen from without.

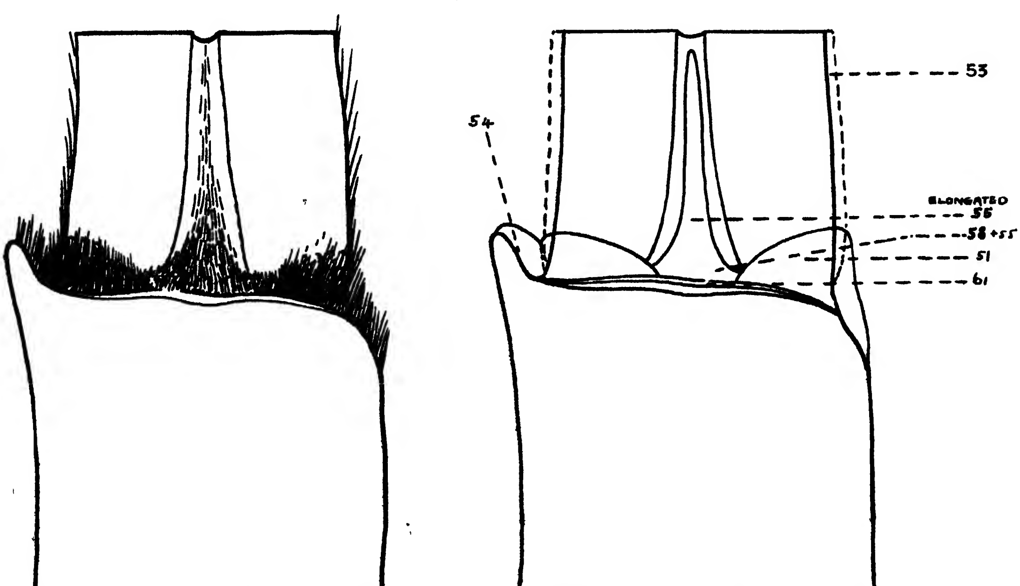


Fig. 15. B. H 146. Juncture of sheath and blade of the leaf with plan showing hairgroups by numbers. Seen from within.

Eyes

Eye attached broadly and set in deep, shape wide oval, flat tip, small wings vanishing at top, veined to central germ pore, slightly humped when young, older distinctly humped, tip turns up very little, medium in size, edge smooth.

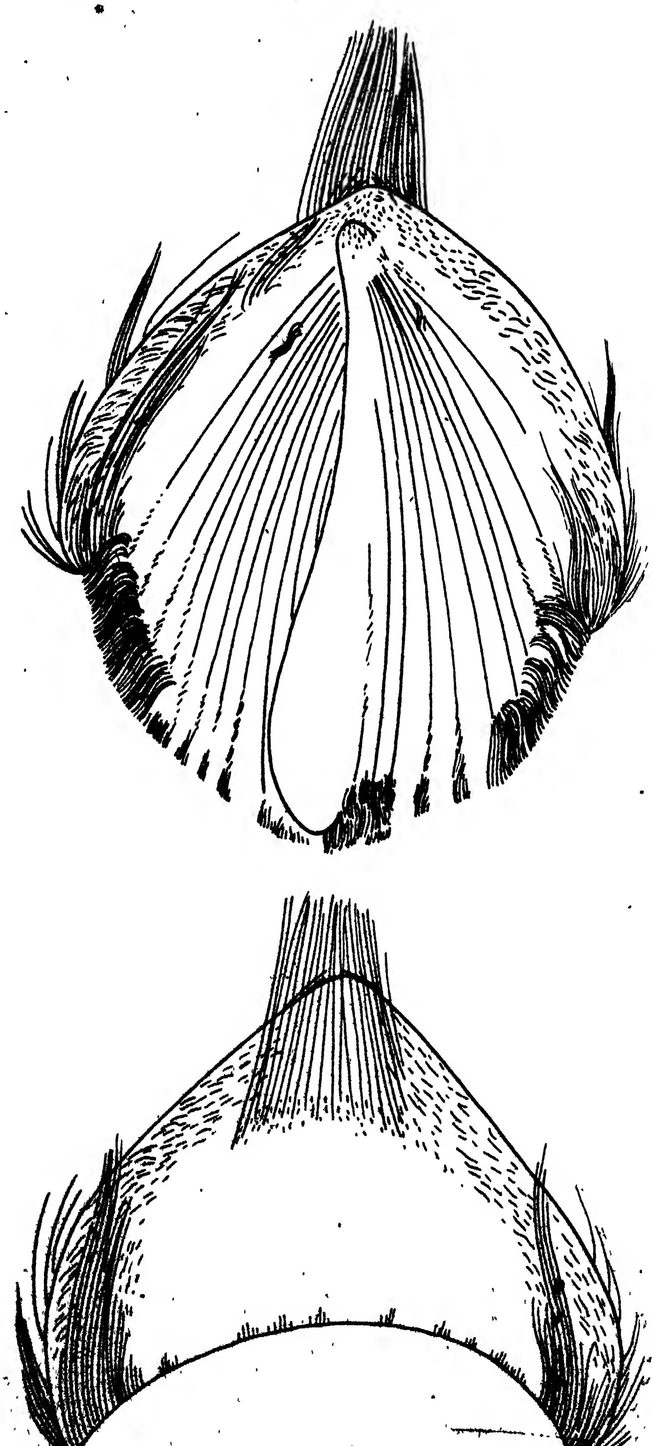


Fig. 16. Yellow Caledonia. Front and back of the eye.

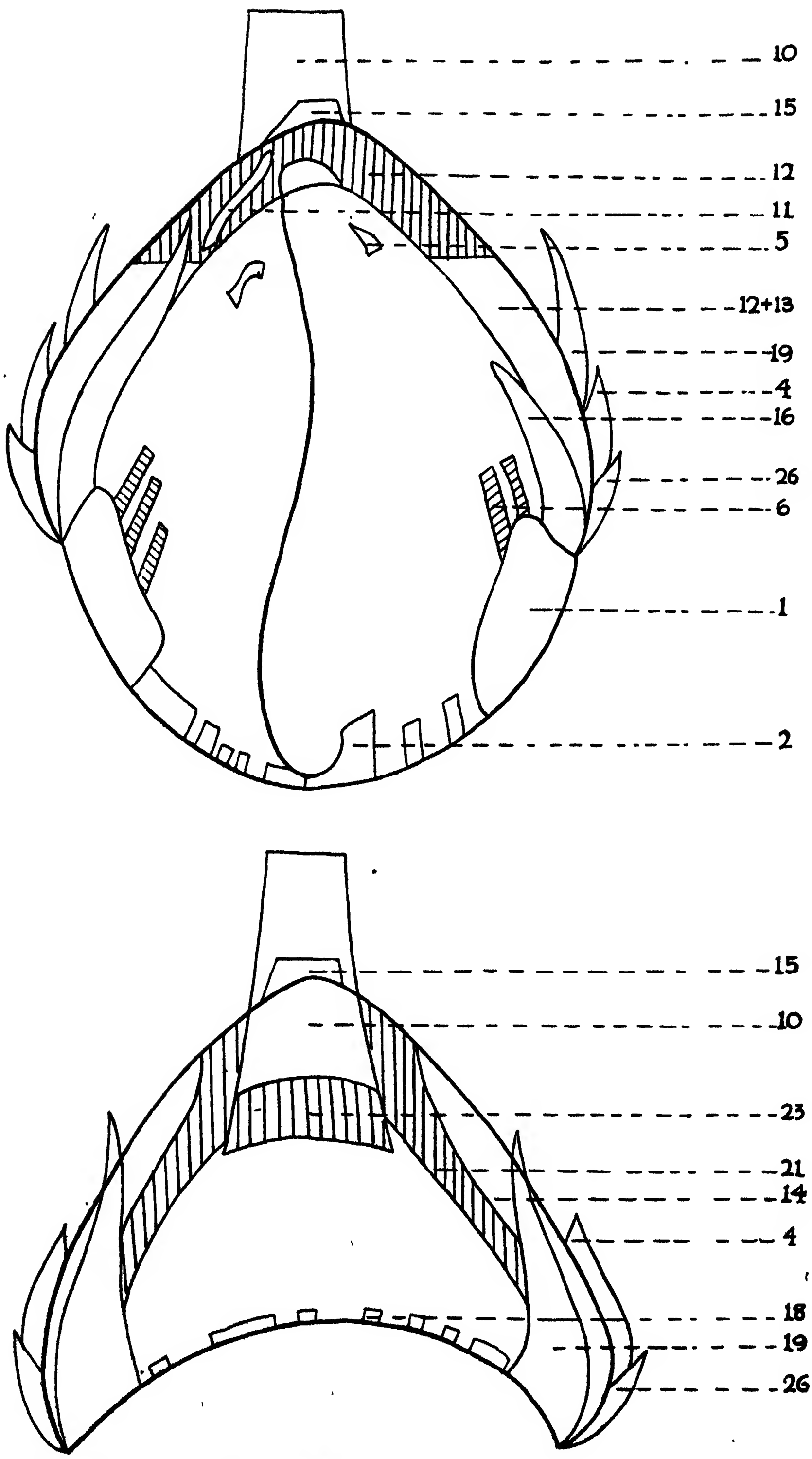
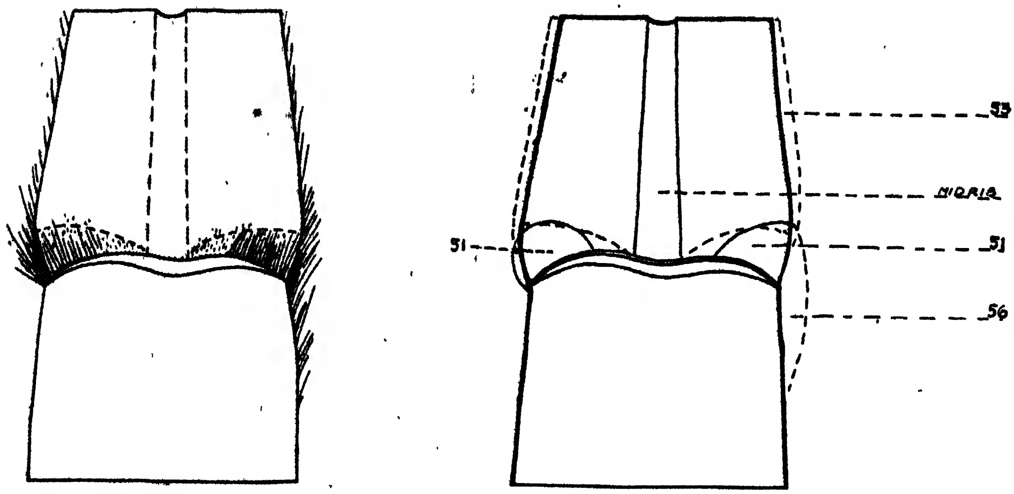


Fig. 17. Yellow Caledonia. Plan of front and back of the eye, with hairgroups by numbers.



A. Yellow Caledonia. Juncture of sheath and blade of the leaf with plan showing hairgroups by numbers. Seen from within.

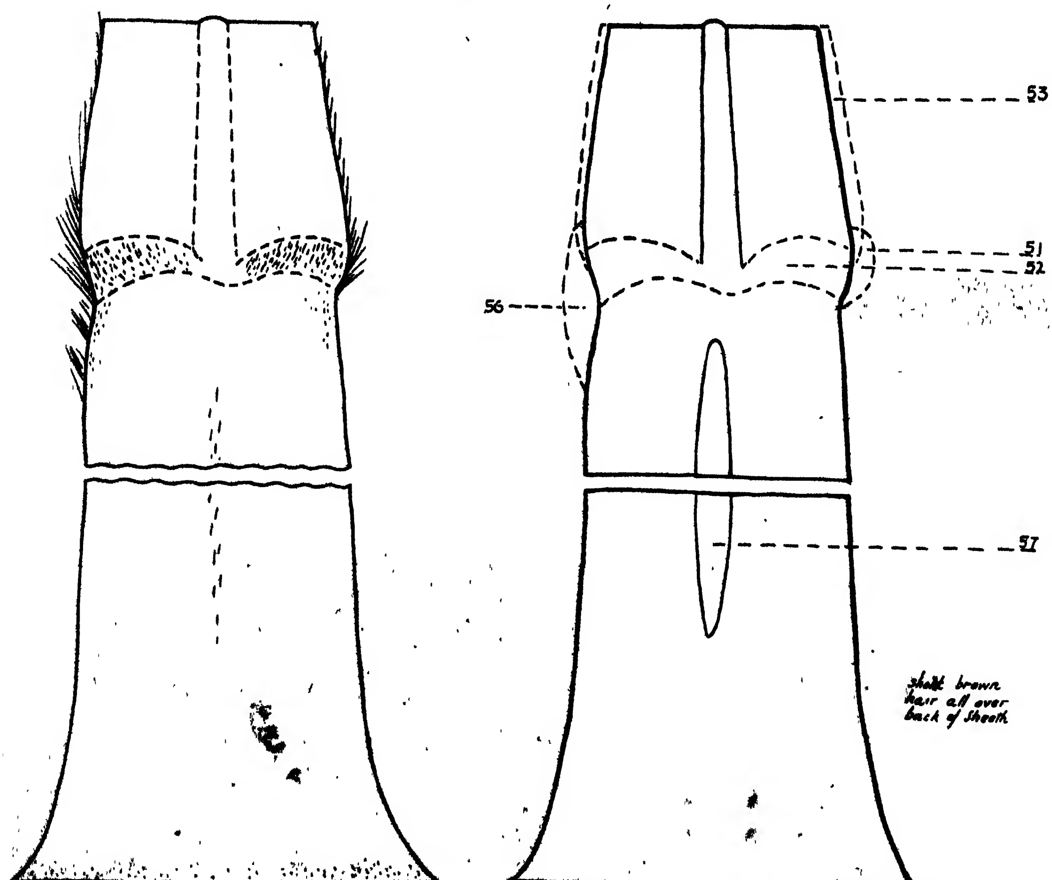


Fig. 18. B. Yellow Caledonia. Sheath and juncture of sheath and blade of the leaf with plan showing hairgroups by numbers. Seen from without.

Yellow Caledonia

General Description of Appearance and Growth

Very tall, heavy, straight, yellow green, later reddish blotches on yellow. Towards maturity brown, yellow and red spots or streaks just above growth ring and many cork cracks.

A very hard cane, leaves broad, very straight, turned over at tip, spotted yellow.

No growth cracks.

Wax layer even and thin.

Wax ring distinct.

Cylindrical internodes, slightly flattened eye side.

Rind fibre uncolored.

Growth ring swollen.

Generally three to four eyes.

Very seldom eye groove.

Eyes

Well developed eyes are egg-round, pointed, narrow winged, strongly arched with uplifted tip, grow tight against stalk, except tip. The wing is narrow, and equal size all round eye.

In the lower joints just above the ground and in young ratoons are eyes of deviating shapes, so-called "coral eyes" entirely or partly locked in a cavity, and with the front side or tip so little developed that one sees the back protruding ahead of the tip.

The Assimilation of Nitrogen by Sugar Cane

Nitrates vs. Ammonia Salts

By W. T. McGeorge

While considerable variation in the nitrogen content of Island sugar lands exists, in general they are high in total nitrogen of low availability. It has been noted on Grove Farm that a plant crop following a fallow will show little or no response to nitrogen applications, but otherwise instances are rare where cane has failed to respond markedly. This applies to virgin as well as cultivated soils. Nitrogen fertilization under the present plantation practice therefore devolves into purely a question of the profitable limit.

Sufficient experimental data have been published to prove the low nitrification or rather a dormant nitrifying power in Hawaiian soils. This is especially true of the acid soils, for example, the Hamakua coast and upland areas on the other islands. In the districts of less rainfall, that is on the irrigated plantations, the soils are less acid, many being alkalin and there is a greater degree of nitrification. As a whole, the cultural methods in vogue are not conducive to the environment productive of high nitrification of the soil nitrogen. In the process of nitrification ammonia represents one stage in the bacterial decomposition of organic forms of nitrogen. In the absence of sufficient aeration or oxygen supply the process is retarded at this point.

While nitrogen as nitrate is best adapted to assimilation by most plants a number of experiments have shown that certain plants will produce a normal growth when supplied with nitrogen in the form of ammonium salts only. For example, of local interest, we may cite the work of Kelley on the assimilation of nitrogen

by the rice plant. In view of the low nitrification in the Island soils Mr. Stewart has suggested a similar study on the assimilation of nitrogen by sugar cane. That is whether ammonium salts can be directly assimilated. In an attempt to throw some light on this question three experiments carried on in sand and water cultures gave the following interesting results:.

Experiment 1.

The object of this experiment was to determine the comparative growth of sugar cane in nutrient cultures varying only in forms of nitrogen, namely, from sodium nitrate and ammonium chloride.

Containers. Three-gallon earthenware jars were used. To each of these 20 pounds of pure silica sand, previously sterilized in an autoclave for 2½ hours at 15 pounds pressure, was added. Tubes and funnels were adapted to permit addition of nutrient solution to the bottom of the pot, to permit aeration and the removal of nutrient when desired.

Seed. Three-eye cuttings of H 109 cane, the ends of which had been painted with paraffin and then allowed to stand in 4 per cent formalin for ten minutes. These were planted about one inch below the surface in the sand.

Nutrient. Nutrient cultures of the following composition were prepared.

No. 1 containing nitrogen as nitrate but no ammonia.

190 p.p. mil. Potassium.
172 p.p. mil. Calcium.
52 p.p. mil. Magnesium.
117 p.p. mil. Phosphate (PO_4).
160 p.p. mil. Nitrogen.
202 p.p. mil. Sulphate (SO_4).

The salts used in making the above included potassium nitrate, calcium nitrate, sodium nitrate, monobasic potassium phosphate and magnesium sulphate. This nutrient had a reaction of pH 5.3.

No. 2 containing nitrogen as ammonium and no nitrate.

190 p.p. mil. Potassium.
172 p.p. mil. Calcium.
52 p.p. mil. Magnesium.
117 p.p. mil. Phosphate (PO_4).
160 p.p. mil. Nitrogen.
202 p.p. mil. Sulphate (SO_4).

The salts used in making the above included ammonium chloride, magnesium sulphate, monobasic potassium phosphate, potassium sulphate and calcium carbonate. A trace of iron as citrate was added to both nutrients. The reaction of this nutrient was pH 4.97.

Twelve hundred cc. of nutrient was added to each pot and the surface of the sand painted with a paraffin-vaseline mixture in order to prevent contamination of the ammonia cultures with nitrifying bacteria. The experiment was run in duplicate, that is two pots of each culture. A set of gravity bottles was used for aeration and for drawing off the old nutrient. The pots were aerated twice each week and the nutrient culture was changed once each week, 500 cc. of fresh nutrient being added to replace that removed.

The seed was planted February 28, 1923.

On March 20, tests for ammonia and nitrate were started on the culture medium. These tests showed the ammonium cultures to be still free of nitrate nitrogen but ammonia was present in the nitrate cultures due to insufficient aeration.

On March 25, the shoot from the seed in one of the nitrate pots had penetrated the paraffin-vaseline surface. On April 10, the shoot in the second nitrate pot had penetrated the surface and it was noted that this shoot had developed from a bud on the under side of the seed and hence was slower in reaching the paraffin-vaseline covering. It should be mentioned that while the germination appears to be very slow the weather at that time was not of the best.

On April 6, the surface covering was removed from the ammonium pots sufficient to observe the development of the seed. There was scarcely any root development, while the seed in the nitrate pots possessed a heavy healthy root system reaching almost to the bottom of the pot. In the ammonia cultures the roots were of a dark brown color and the buds gave no appearance of development. The paraffin-vaseline surface was again applied and the experiment continued without disturbance.

Nitrate tests on the nutrient culture from the ammonium pots were made each week up to the termination of the experiment without at any time obtaining a positive test. In view of the delicacy of this phenoldisulphonic acid test for nitrates, this gives absolute assurance of the absence of nitrate in the cultures.

On June 15, practically four months after planting, the experiment was discontinued without any appearance of shoots from the ammonia cultures at this time.

The comparative appearance of the root systems is best illustrated by the accompanying illustration in Plate 1. A brief description of the condition of the plants follows.

Nitrate cultures: These plants had developed a mass of main roots abundantly supplied with root hairs. The main roots shaded in color from a healthy reddish brown to yellow with the root hairs almost white. The length of plant above the surface was 60 inches and of the roots 16 inches.

Ammonium cultures: The seed appeared to be dead in so far as any indication of germination was concerned but was still solid and although quite dark in color there was little or no indication of decay after having been planted four months. One bud had swollen and reached a length of about ¼ inch and another ½ inch. The roots showed some development, but most were dark and stubby. On one seed there were ten roots of measurable length, the longest being 1½ inches, all were black except the tips of three, which had a slight indication of life (a pale yellow color at the tip). There were no root hairs. In the seed from the second ammonium culture pot there were eleven roots of measurable length and all similar to those already described, lacking root hairs.

Experiment 2

In view of the absence of bud germination and extremely faint root development, and in the absence of nitrates and nitrifying bacteria, further attempts to grow with ammonium salts as the only source of nitrogen were made. In this ex-

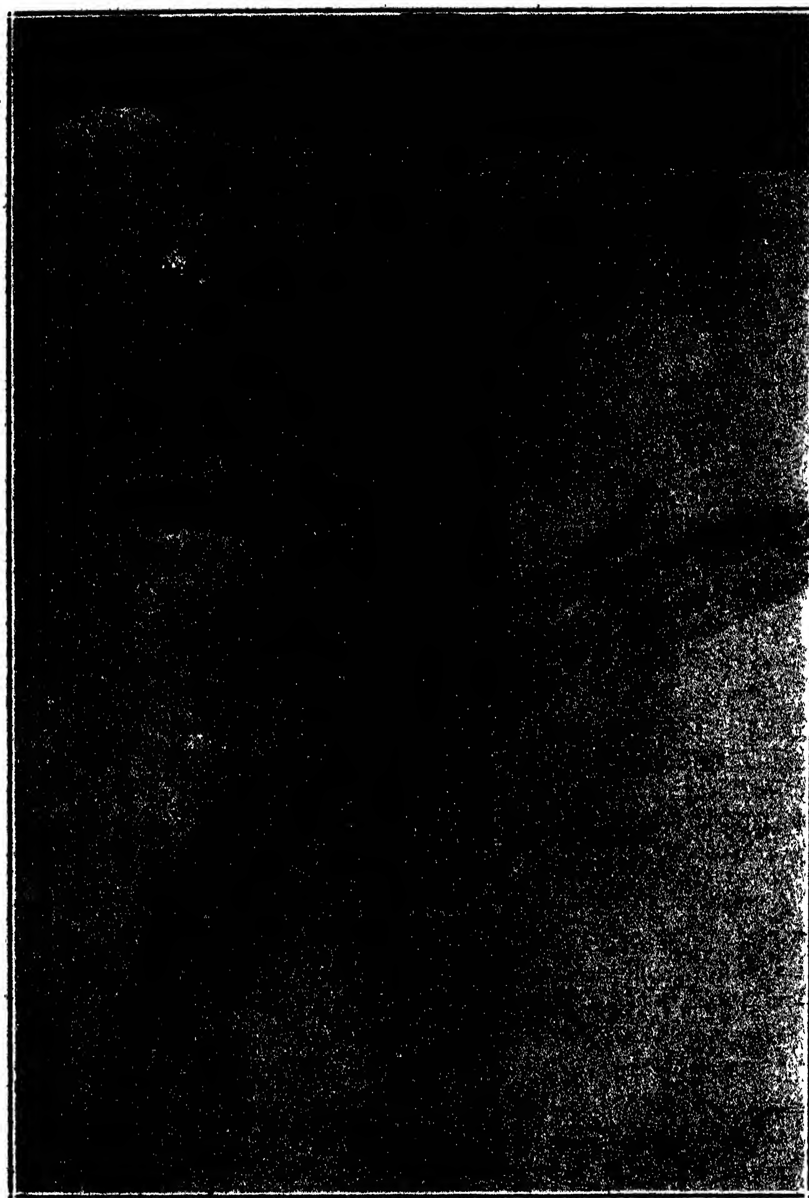


Plate 1.

periment the seed was not entirely covered, thus allowing some contact with the air. In Experiment 1 the vaseline-paraffin coating was applied to the surface of the sand to prevent the chance entrance of nitrifying bacteria, thus giving assurance of their absence. In Experiment 2 this was omitted in order to give the seed better contact with the air. This experiment included attempts to grow in both water and sand cultures.

1. An eight hundred cc. beaker was placed inside a 1.5-litre beaker, H 109 seed, prepared as previously described, placed on the 800 cc. beaker which acted as a support. Nutrient culture solution No. 2 was added to such a volume as to leave one-half the seed exposed to the air. The nutrient was changed each week and the old solution tested for nitrates. A positive test for nitrate was obtained on the

eighteenth day. At this point the shoots were well developed and growing normally. On account of the appearance of nitrate at this point the experiment was discontinued.

2. In this part of the experiment 1.3-litre beakers were filled with sterilized sand and the seed planted leaving a portion of the surface uncovered. The whole was then saturated with nutrient solution No. 2. Three shoots germinated in one seed and grew to 7, 6 and 22 inches respectively, at which point the leaves began to yellow and soon dried up. Yellowing commenced seven weeks after planting and three weeks later the plant was dead. The duplicate, having only one shoot, retained a normal appearance for a longer time, remaining green two weeks longer, but dying more rapidly after the leaves began to yellow. Tests for nitrate in these sand cultures at numerous intervals gave negative results. The roots were very similar in appearance to the description given in Experiment 1, except that they were slightly longer and further developed.

Experiment 3

In view of the appearance of nitrate in the water cultures in Experiment 2 this experiment was repeated as was also the sand culture for confirmation. The same procedure described in Experiment 2 was followed except that the water and sand cultures were sterilized in the beakers ready for planting and seed planted as soon as cool.

The seed was planted May 2, and on May 16 that in the sand culture had just sprouted while in the water culture the shoot was four inches long and fair

Plate 2.

root development had started. The leaves continued to develop normally until May 9, five weeks after planting, when they were yellowing rapidly. At this time the shoot in the sand culture was 4 inches long while in the water culture they were 8½ and 2 inches. The yellowing always started at the tips, first assuming a reddish color. In the sand culture the plant was dead on June 16, while in the water culture it lived one week longer. The examination of the roots showed the same condition already described under Experiments 1 and 2. Plate 2 illustrates more clearly the appearance of the plants at this time. At no period did the roots have a normal color or appearance. Periodical tests for nitrate during the growth of the cane and at the conclusion of the experimnet were all negative.

Conclusions

While results obtained on such a small scale as here described are mainly indicative, they clearly show the vital role which nitrates play in the growth and development of sugar cane.

It is significant that nitrates function to a great extent as a root stimulant while, ammonium salts decidedly inhibit their development.

A Simple Cure for Sereh

In an article recently published—Miss Wilbrink*, botanist of the subdivision Cheribon of the Experiment Station of the Java Sugar Industry, announces the discovery of a cure for the Sereh disease of sugar cane.

Early in their experience with Sereh, the Java planters learned that as a rule cuttings taken from diseased canes gave rise, when planted, to diseased plants.

Miss Wilbrink has now demonstrated that if cuttings from plants having Sereh are immersed for half an hour in water maintained at a temperature of from 52 degrees to 55 degree C., the causative agent of the disease is destroyed and that cuttings so treated will, when planted, give rise to healthy canes.

Miss Wilbrink resorted to the hot water treatment of cuttings in an attempt to differentiate between Sereh and the Gumming disease of Java. The latter disease, she had previously shown to be due to a bacterium which was killed by a temperature of 52 degrees C. In her recent experiments, she found that all cuttings infected with Gumming disease were killed outright by the hot water treatment while cuttings infected with Sereh might survive, but were freed from the disease.

Miss Wilbrink does not recommend this treatment for use on a large scale because the temperature required to kill the Sereh infection is very close to the thermal death point for sugar cane cuttings and invariably a percentage of the cuttings treated will fail to grow. It is, however, applicable on small scale plant-

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* Wilbrink, G. Warmwaterbehandeling van stekken als Geneesmiddel tegen de Serehziekte van het Suikerriet. Mededeelingen van het Proefstation voor de Java-Suikerindustrie. Jaargang 1923, No. 1.

ings and is of especial value to experimenters and cane breeders who have occasion to work with small areas of various varieties and wish to keep them free from Sereh and Gumming disease.

We have, for many years, refrained from importing sugar cane varieties from Java for fear of introducing Sereh into Hawaii. Miss Wilbrink's discovery puts an entirely different complexion on the matter for it places in our hands a simple and effective means of destroying any Sereh infection that might accompany the cuttings which we import. It would, at the same time, afford us certain protection against the Java Gumming disease which would be quite as unwelcome an introduction as Sereh.

During the course of her experiments, Miss Wilbrink tested the value of the hot water treatment as a destroyer of the virus of mosaic of sugar cane and found that it had none. This result is in accord with those obtained by other workers with mosaic diseases for in general it has been found that the virus of a mosaic will survive any temperature survived by the host.

Through the kind assistance of Mr. Duker, we have secured a complete translation of Miss Wilbrink's paper and, in the following paragraphs, we quote the substance of some of her more interesting and important statements:

A Dane, Mr. J. L. Jensen of Kopenhagen, was the first person who employed heat as a cure for plant diseases and demonstrated that wheat-seed could be freed from the spores of Smut by treatment in a warm water bath. Jensen's publications on this subject appeared in 1888. These investigations attracted general attention in the scientific world but found little approval at first, although those who carefully checked up Jensen's work had to admit that he was right. Although Jensen himself concluded that his method was too elaborate for practical use and recommended a treatment with chemical disinfectants, still the warm water treatment was successfully introduced to the farmers in Denmark years after by van Ravn and Mortensen. In recent years, there has been a rather extended application of heat as a cure in the flower bulb industry for the growers strive to free their bulbs from nematodes either by means of heated air or a warm water bath.

In the first years of the appearance of the Sereh disease they not only tried to cure the Sereh-diseased cuttings by means of chemical disinfectants such as corrosive sublimate, copper sulfate, potassium permanganate, zinc-sulfate, chloride of lime, molasses and bromide water, but warm water baths were also tried at that time. As far back as 1889, we find that Mr. J. Sayers at Gemoe, perhaps as a consequence of Jensen's investigation, suggested experiments with warm water treatment of cane cuttings as a cure for Sereh, and particulars were published in a pamphlet issued that year.

From this pamphlet as well as from opinions of Kramers and Kobus in the Communications of the Experiment Station, East Java, we understand that Sayers recommended a heating of the cane cuttings during 10 minutes to 50 degrees Centigrade.

As a consequence of these suggestions, Kobus made some experiments in 1889 with warm water treatment of Sereh-diseased cane. Although he mentions that cane cuttings can stand heating one hour in water of 50-52 degrees Centigrade, he did not go higher in his experiments than 50 degrees C., which temperature he kept up for one hour.

The seed thus treated gave a little higher yield than the untreated, but whether or not the percentage of Sereh was reduced by the warm water treatment is not mentioned.

Further experiments were not made by Kobus because he considered the method too cumbersome for practical purposes and in more recent literature we find no further mention of a warm water treatment.

The discontinuation of experiments may also have been caused by the fact that in 1891, Dr. Janse, botanist of the National Botanical garden, published investigations by which he claimed to have demonstrated that Sereh was caused by a bacterium which could stand the temperature of boiling water. At first the conclusions of Janse were accepted, for even so prudent a research worker as Dr. Valeton was thrown off the track and as

long as the impression existed that the Sereh parasite could stand the boiling temperature all hopes of curing Sereh-diseased cuttings by a warm water treatment were naturally abandoned, because the cuttings themselves would surely not be able to withstand so high a temperature.

By the time that it became evident that the contention of Janse was a mistake caused by an incorrect method of isolation, the growing of mountain-seed had demonstrated its great effectiveness in the fight against Sereh, and because the cane remained healthy in the cooler regions, the thought of heat as a cure was given up.

We took it up again when we looked for a method by which the difference between gum disease and Sereh could be demonstrated. A few years ago, the opinion existed that Sereh was nothing more nor less than a chronic form of gum disease and that, therefore, both diseases had the same cause.

Our investigation of gum disease showed this conclusion to be erroneous but even after our publication, the opinion that there was no real difference between the two diseases continued to exist and this we considered undesirable. Therefore, we looked for a method by which we could demonstrate the difference between Sereh and gum disease in such a manner as would be accepted by everyone. The cause of the gum disease is a bacterium which dies at a temperature of about 52 degrees Centigrade.

In a treatise by Dr. E. van Slogteren, we find that the disease of the hyacinths, a disease closely related to gum disease, can be cured with a warm water treatment and this indicated to us the possibility of thus killing the bacteria of the gum disease in the cuttings.

As far as the Sereh disease is concerned, we began more and more to believe in the theory of Prof. Quanjer that this disease was bound to be closely related to the curl-disease of the sugar-beets and the leaf-roll disease of the potato, all of which come close to the mosaic diseases.

The infectious matter of the mosaic diseases proved to be able to withstand high temperatures. Therefore, it appeared to us probable that Sereh-diseased cuttings could find no cure by the application of a warm water bath, whereas it must be possible to kill the infectious matter of the gum disease by such a treatment.

Our first experiments were made during the planting time in 1921. As up to that time the observations by Kobus on warm water treatment of cane cuttings had escaped our attention, we determined first, by preliminary tests, how much heat the cane cuttings could stand. We used, therefore, top seed of E. K. 28 and because this cane also proved to be a resistant variety on this point, somewhat too favorable results were obtained. For instance, no detrimental influence in germination was noticed by heating to 52 at 55 degrees Centigrade for half an hour, a temperature as we found later which most varieties cannot stand.

In our first experiments with gum-diseased and Sereh-diseased cane, which were made on the varieties Black Cheribon and White Preanger, we applied such high temperatures as proved to be rather harmful to the germinating power, but which gave very definite results. And not only did they prove to be definite but a great surprise as well. Of the Black Cheribon, we had at our disposal both gum-diseased and Sereh-diseased cane, but of the White Preanger we had Sereh-diseased cane only.

The gum-diseased cuttings of the Black Cheribon proved to withstand a warm water treatment very poorly. The germination here is slow anyway and by a warm water bath it was entirely destroyed. This result was always corroborated in later tests wherein the temperature did not exceed 52 degrees Centigrade. The chances, therefore, are small to cure gum-diseased cuttings by a warm water treatment. Gum-diseased cane apparently dies off at a lower temperature than the healthy material, and it might, therefore, be possible to thus separate the plant material, but because I did not have a sufficient quantity of gum-diseased cane at my disposal, I have not been able to settle this point.

The experience with gum-diseased cane checks with the results obtained when submitting yellow-diseased hyacinths to a warm water ~~treatment and not~~ this, but the behavior of the Sereh-diseased cane was the real surprise.

Of the Black Cheribon the plant material consisted of top-seed and water-soaked seed of Sereh-diseased crop cane. Warm water treatments at from 52-55 degrees were tried for half an hour and for fifteen minutes, whereas a control plot of untreated seed was also planted.

The germination, which was poor anyhow for this seed, seemed to have suffered considerably, but of each kind a number of plants survived and it was extremely interesting to watch the difference in development. The seed, which was heated for half an hour, produced well growing plants with beautiful dark green leaves; the seed which was treated fifteen minutes produced somewhat less regular plants, whereas the untreated seed produced mostly Sereh-diseased plants with yellow-tinted leaves.

The experiment was harvested on February 25, 1922, and every stalk in every stool was analyzed for Sereh with the results as noted in the table, a stool being considered as Sereh diseased when one stick only showed signs of it.

EXPERIMENT 1A.

Cane variety: Black Cheribon.

Seed: Top seed and water-soaked, body-seed of Sereh-diseased crop cane on experimental field.

Treatment	Number of Cuttings Planted 7/23–1921	Number of Cuttings Germinated 9/6–1921	Harvested 2/25–1922 No. of Stools Healthy	No. of Stools Diseased	No. of Sticks Healthy	No. of Sticks Diseased
A. Heated for 30′ in water from 52-55 deg. C.........	24	9	9	0	68	0
B. Heated for 15′ in water from 52-55 deg. C.........	24	13	9	4	68	22
C. Not heated	24	17	5	12	25	94

The result of this investigation was, therefore, in accord with the observation made on the standing cane. The seed heated for half an hour produced healthy plants only; the seed treated 15 minutes produced largely healthy plants and the non-treated seed gave largely badly affected cane.

In order now to find if the plants considered as cured really remained healthy the seed from the Series A was planted again. Part of the cuttings were again submitted to a warm water treatment, but as may be seen from Experiment 1B, the untreated cuttings produced healthy cane with only one exception and of this stool only one stick was diseased.

EXPERIMENT 1B.

Cane variety: Black Cheribon.

Seed variety: 1st and 2nd seed from Series A, Experiment 1a.

Treatment	Number of Cuttings Planted 2/28–1922	Number of Cuttings Germinated 3/17–1922	Harvested 8/1–1922 No. of Stools Healthy	No. of Stools Diseased	No. of Sticks Healthy	No. of Sticks Diseased
Aa. Heated for 30′ in water of 45-50 deg. C. thereafter 30′ in water of 50-53 deg. C.	50	28	28	0	66	0
Ab. Heated for 30′ in water from 45-50 deg. C. thereafter 30′ in water from 50-52 deg. C................	50	38	38	0	92	0
Ac. Not heated	50	49	48	1	137	1

The warm water bath, therefore, had actually freed the cane from Sereh.

Miss Wilbrink gives the details of experiments with other varieties of cane, all of which corroborate the results obtained with Black Cheribon.

From the evidence presented, we may safely conclude that she has discovered a simple but sure method of ridding cane cuttings of the agent which causes Sereh

H. L. L.

Selection of Seedlings

On the opposite page, we present a sketch giving an outline of the methods we are now following in our seedling work.

Field Test 1 is the first planting in the field, from the nursery pots, of the seedlings germinated from the tassels. In Field Test 1, each stool represents a different variety, in that each stool is from a single cane seed, and not a cutting. We have never yet raised two seedlings which were alike in all respects. When from one to two years old, Field Test 1 is selected and the selected canes are planted to Field Test 2. In this selection we discard from 50 to 90% of the seedlings, depending on their quality and also on the area of land available for planting. Field Test 2 is selected and planted to Field Test 3 in the same way. Each "Field Test" represents a selection. Field Test 4 indicates that that series of seedlings have been selected four times.

Seedlings remaining in Field Test 4 are of good promise and are then planted into regular field experiments against standard canes.

Ratooning a Field Test does not change its number. If Field Test 2 plant is ratooned it becomes Field Test 2, first ratoons, etc.

In order to further identify the different seedlings, we add to the Field Test number the year of propagation. Field Test 1, 1923 propagation, means the first field planting of seedlings raised from tassels collected in the 1922-23 tassel season.

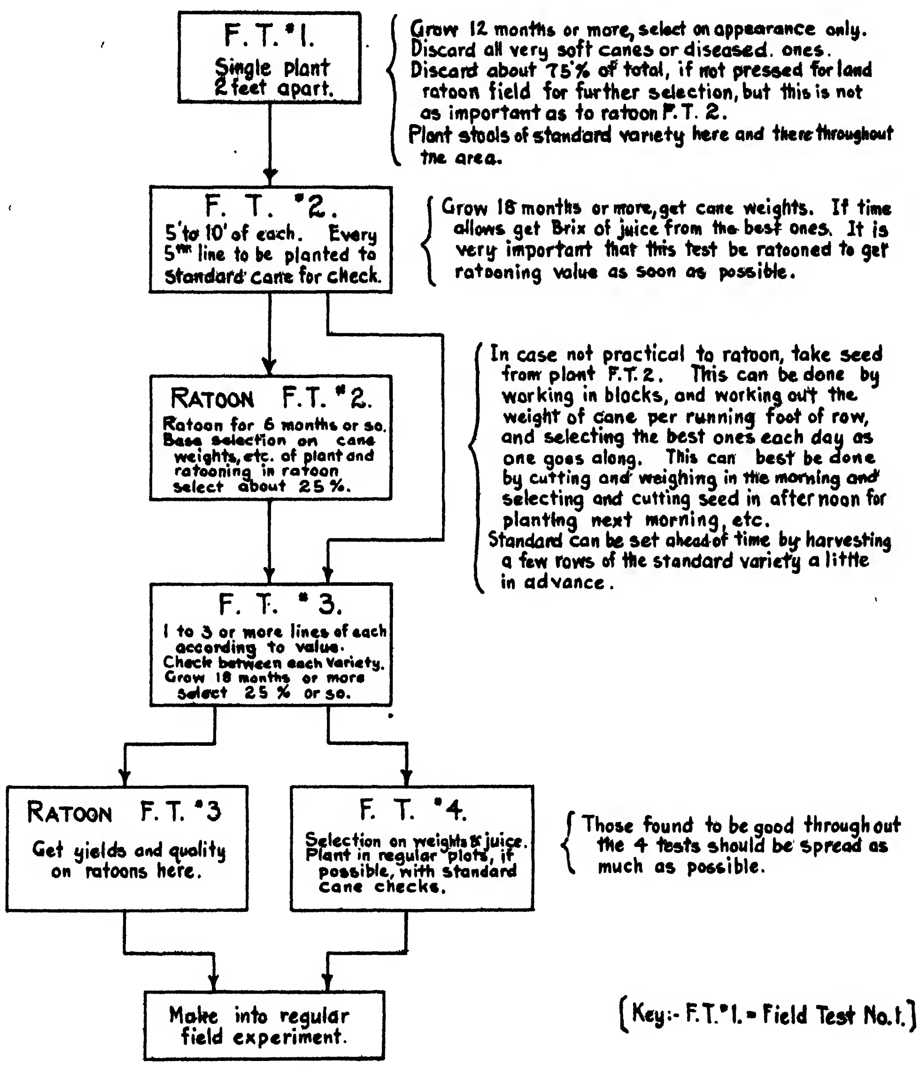
In Field Test 1, the individual seedlings of one parentage are planted together, that is, all H 109 together, all Lahainas, etc., and are given temporary field numbers. It is very important to keep this numbering straight, as in the selection of seedlings it is essential to be able to trace the individuals back from plant to ratoon. To be good, a seedling *must* be a good ratooner in addition to producing a good crop of plant cane.

As soon as a seedling is deemed good enough to be spread and tested against the standard canes, it is then given a permanent number.

We have recently adopted the policy of naming a seedling after the place or plantation where it is first developed into a promising cane. So, we now have Wailuku seedlings 1 to 53, Makaweli 1 to 4, Honokaa 1, and a number of Tip seedlings developed at Kohala Sugar Company known as Kohala 75, 86, 117, 202, and a number of others.

J. A. V.

OUTLINE OF SEEDLING SELECTION



In planting, use a "3-eye" seed piece from which two eyes are gouged out. Let the best eye be kept and cut the seed so that the best eye is in the middle. Plant one eye per foot. In wireworm country, or where general conditions are poor, use twice the amount given above. Plant 2 or 3 extra seed per each 10 feet to replace any misses. When the stand is full, destroy extra shoots, leaving one per running foot.

Use good seed, and of the kind which experience has shown is best in that district. The percent to be selected or discarded as indicated above is more or less nominal and will vary within very large limits depending upon conditions.

J. A. V.

Kauai Seedling Propagation

By Olen C. Markwell

In order to give the reader a simple perspective of the progress of seedling work on Kauai, the accompanying chart was made, showing chronologically the work from 1917 as started by R. S. Thurston, continuing through the years 1920-'21-'22 by J. H. Midkiff, and carried on in '22 and '23 by the writer. It is my desire to show clearly just where each propagation stands today and to make a reasonable forecast of what the results will be.

I find that since 1917, 47,923 seedling cane plants have been set to Field Tests No. 1. From these, 6,963 were found to be of promise and were planted to Field Test No. 2. Unfortunately, 797 seedlings of Field Test No. 2 were lost. At McBryde Sugar Company, Field Test No. 2, 1917 propagation, made up of 303 seedlings, through misunderstanding was plowed up; Field Test No. 2, 1919-'20 propagation at Lihue Plantation Company was also plowed out.

There are four Field Tests No. 3, in which are found 424 seedlings. Some of these seedlings have gone into Field Test No. 4, so that today the Hawaiian Sugar Company has 35 seedlings and McBryde Sugar Company 108 seedlings in Field Test No. 4, plant crop.

The question arises as to the standard of selection used. From the total of the various field tests we have the following:

Field Test Number	Total Seedlings	% Selection For Subsequent Field Test
1	41,096*	16.9
2	6,963	6.1
3	424	17.9
4	76 & 77	

In Field Test No. 4 the figure 76 was used, for 76 seedlings came through Field Test No. 3, while 77 seedlings were taken from Field Test No. 1, old ratoons.

With the exception of some seedlings at Makee Sugar Company and a few at Koloa and Kilauea plantations, the Hawaiian Sugar Company and McBryde Sugar Company hold the most promising ones. They not only hold the bulk and promise of Kauai seedlings, but they have carried them further, consequently are ready for a more comprehensive study than heretofore has been given them.

Mr. Poole, Selectionist for the Hawaiian Sugar Company and McBryde Sugar Company, is now at work in this area.

In the beginning, it was made quite clear to me that Kauai was reaching out for a good "ratooner". To find and develop such a cane, it is obvious that one must work for a number of years, ratooning the seedling areas and basing the selections on the ratooning qualities of the different seedlings.

Even in these advanced field tests it is not possible to say that any one of the good canes is uniformly superior. If there is any one quality that proves a

*This does not include the areas which were plowed out.

stumbling block and often a bitter disappointment to the selectionist of seedling canes, it is uniformity. Whether some of the seedlings are actually sporting at a tremendous rate or if the lack of stability is due to some other cause, not inherent, I cannot say. While I have no data to substantiate the statement, I do know that the individuals of the seedlings vary widely.

Hawaiian Sugar Company's Seedlings

Field Test No. 4, 1918 propagation, Hawaiian Sugar Company, is a plant crop containing 35 seedlings, planted September, 1922. The seed was cut from Field Test No. 2 of that prapagation, first ratoons, after a careful study of data from the harvest of Field Test No. 3, plant at that time. In addition to the mill data, a thorough observation of the Field Test No. 2 revealed seven canes of strong ratooning power. These were also planted, therefore we have:

Propagation	Plantation	F. T. No. 2	F. T. No. 3	F. T. No. 4
1918	Hawaiian Sugar Co.	2nd ratoon	1st ratoon	Plant

The time is at hand for a detailed study and thorough checking up of the ratooning behavior of all the seedlings in Field Test No. 4 and at the same time to bring under observation good ratooners which have been overlooked or for some unknown cause have come to the front.

Mr. Poole has made a cursory study of the 1918 propagation, but at this time he has nothing to give in the way of an accurate checking up.

While the mill data is a very desirable guide in selecting for planting to advanced field tests such data is far from infallible, e. g. No. 90 (now Makaweli No. 1), the "whale" of the entire propagation giving 16 tons of sugar per acre when weighed and sampled in Field Test No. 3, plant, is a poor ratooner in first ratoons there, looks fairly well in plant Field Test No. 4, and a fair ratooner in second ratoons in Field Test No. 2. Taken all in all the "pick" of Kauai seedlings are to be found in the Hawaiian Sugar Company's fields.

In the 1919 propagation, the Field Test No. 2 lies alongside of Field Test No. 3 of 1918 propagation and compares very favorably with it. There are 632 seedlings in this field test, many of them promising. Mr. Poole is making observations on them. Selecting and planting should be done here soon.

During June, 1923, the 1920 propagation, consisting of 403 seedlings, was weighed and sampled. Not much importance had been attached to these seedlings, although they had been observed, but the harvesting results showed that many of them were equal to or better than the H 109 checks. After a study of the mill data, it was found that 95 of them were good. The ratooning quality of these will be noted with interest.

While the 1921 propagation, containing 17 seedlings, has been carried to Field Test No. 2, nothing is outstanding.

One might question the desirability of Badila seedlings at Makaweli. However, the 1922 propagation contained 40 seedlings of that parentage. Thirteen of these looked promising and were planted along with 33 seedlings of other parentages to Field Test No. 2, 1922 propagation. They are doing nicely.

McBryde Sugar Company's Seedlings

Field Test No. 4, 1918 propagation, is too young to have its value intelligently estimated. Seventy-six of its 153 seedlings were taken from first ratoons Field Test No. 3, while 77 of them were taken from "old ratoons" Field Test No. 1.

Field Test No. 2, 1919 propagation, second ratoons, contains 237 seedlings. These ratoons have not yet been thoroughly checked, so one cannot be sure as to how many should be carried to Field Test No. 3, but the mill data show 15 to 18% as promising.

You will note that here we are to select from second ratoons Field Test No. 2 for the planting of Field Test No. 3. This is a bit unusual, but since we are seeking a mauka cane which is a good ratooner, we may discover a short cut by eliminating the bad ones here rather than Field Test No. 3. It is a question whether we are not doing too much work on plant cane while looking for ratooners. I know the object is to find "the cane", nevertheless it creates a favorable impression to have the tons-of-sugar-per-acre for the seedling area as good as that of the crop cane.

Mr. Alexander, manager of McBryde Sugar Company, has desired that the work in seedlings be under mauka conditions, He said, "We must have a mauka cane," consequently these seedlings were put to a severe test. Scarcity of labor, low temperature, and the constant encroachment of weeds have given the largest and most promising propagation a fight for its life. Field Test No. 2, 1920 propagation, has suffered. When this field test was first planted there was a shortage of labor and water, so the seedlings necessarily were neglected.

In December, 1922, and January, 1923, the 2,566 seedlings and their checks were weighed and more than 500 samples taken. A study of the mill data placed 246 as equal to or better than the check D 1135. One should not anticipate good ratoons from all of these 246, consequently Field Test No. 3 may be less than that number.

I find that Field Test No. 2, 1920 propagation, was planted in three installments, in reality three selections from Field Test No. 1.

Mr. J. H. Midkiff said that he and one helper, Mr. King, I believe, went over Field Test No. 1 selecting about 700 seedlings, later the field test was re-selected and between 1,000 and 1,200 were taken, and at a later date the field test was again reselected and 500 additional ones taken.

This first selection was planted to 700 approximately (see blue print No. 118), the second selection to about 1,900 (see blue print No. 119) and the third selection planted the remainder.

In weighing and sampling this Field Test No. 2 fully seventy-five percent of the desirable canes fell within this first selection, the second selection was much poorer, and the third was almost worthless. One cannot say positively that this wide difference was due to higher standard of selection, for soil variation may have entered, but I do think that to selection a part of this difference was due.*

J. A. V.

* Results of a similar nature have been obtained in Honolulu in the 1918 propagation. The 8900 series comes from about 104 seedlings which were considered the most promising on the first selection. The remaining couple of thousand 1918 O. P. seedlings have but 3 or 4 promising canes left.

The 1917 propagation met with disaster. A misunderstanding led to the plowing up of this field test area early in 1922. Since it did not receive a thorough plowing, it may be possible to find among the H 109 planted there any outstanding seedlings which may have survived. Perhaps it would be well to go thru this area and look for such late in August or early in September of this year.

Koloa Sugar Company

Koloa Sugar Company 1920 propagation has been planted under makai and mauka conditions. Even though a cane may not prove desirable makai owing to its failure to give a maximum response to optimum conditions—soil, temperature, light, water, and fertilizers—it may prove a profitable one for mauka conditions. A cane which is vigorous and ratoons well is always desirable. If any cane possesses these qualities, it is worth while to try it mauka.

Of the 1920 propagation there are 21 seedlings of fair promise. The Wailuku seedlings and various other seedlings sent over from Honolulu are doing nicely.

Makee Sugar Company

Of the 1920 propagation Makee has 840 seedlings of first ratoons Field Test No. 2. During February, 1923, these seedlings were weighed and sampled. Mill data leads us to believe that 46 of them are equal to or better than the check H 109.

Lihue Plantation Company

Last November, Mr. Kutsunai and I went through the area of the 1919-1920 propagations, Lihue Plantation Company, and flagged the seedlings which looked promising. This seedling area, as a whole, looked poor so it was plowed up by the plantation in March, 1923.

Kilauea Sugar Plantation Company

Kilauea Sugar Plantation Company's seedlings consist of 17 Kauai propagation 1919, 1913, '14, '15 and '17 Oahu propagation, and a number of Badila seedlings. Of the seedlings at Kilauea the ones of Badila parentage are most promising. It might be well to have more seedlings of Badila parentage under the mauka conditions of Kauai.

Grove Farm Plantation Company, Ltd.

The 1918 and 1919 propagation have shown no seedling of promise. Of the 1918 propagation none have gone to Field Test No. 3. However, of the 1919 propagation two were planted, but they are not unusual. I notice that many of the seedlings had yellow stripe, which was taken care of. As this field test is active the ratoons will be observed.

General

Computed on a basis of total seedlings in Field Test No. 2 of all propagations on Kauai, there are at present, as the data at hand show, 6,963 seedlings. These are distributed as follows:

Plantation	Seedlings in F. T. No. 2	Percent of Total Seedlings
McBryde Sugar Co.	4140	59.6
Hawaiian Sugar Co.	1682	25.5
All other	1141	14.9

Because the McBryde seedlings are grown under adverse conditions, the total number to reach Field Test No. 4 will be relatively small. Since "all other" plantations on Kauai have only 14.9% of the total Field Test No. 2 seedlings, obviously they need more.

If these are to be propagated here, the work of planting, observing, and selecting them could be carried on more advantageously if one plantation should take one year's propagation, e. g. Grove Farm Company, Ltd., 1924; Lihue Plantation Company, 1925, etc.

A difficult problem to meet is the numerous propagations on the various plantations. Since a luna doesn't think of seedlings in terms of propagation years, the above condition frequently gives rise to misunderstanding which results in confusion in seedling work. The average luna has all he can do to look after the crop cane, which is of immediate importance.

In all the seedling work on Kauai, there has been a sincere spirit of cooperation expressed by the many helpful suggestions and personal observations on the part of managers and lunas, without which progress in seedling work would be seriously impaired.

Summary

1. Total Field Test No. 2 seedlings all propagations (Kauai) is 6,963. McBryde Sugar Company has 59.6% of these; Hawaiian Sugar Company 25.5%; other plantations 14.9%.

2. Advanced seedlings are:

Plantation	Propagation	F. T. No. 1	F. T. No. 2 2nd ratoon	F. T. No. 3 1st ratoon	F. T. No. 4 Plant
Hawaiian Sugar Co.	1918	0	594	113	35
McBryde	1918	0	1337	281	31–37

3. At present, considerable time should be given to canes of the above field tests in order to check ratooning quality as shown in Field Tests Nos. 2 and 3. More stress should be put upon descriptive work of these canes.

4. Field Test No. 2, 1920 propagation, McBryde indicates that a fairly close selection is desirable.

5. In the future it might be advantageous to allot to the various plantations propagations by years.

KAUAI SEEDLINGS 1923.

Propagation Year	Plantation	No. of Active F. T.'s	F. T. No. 1 Active	F. T. No. 1 No. of Seedlings	F. T. No. 2 No. of Seedlings	F. T. No. 2 Ratoon	F. T. No. 3 No. of Seedlings	F. T. No. 3 Ratoon	F. T. No. 4 No. of Seedlings	F. T. No. 4 Ratoon	Remarks
1917	McBryde Sugar Co...	1	No	908	303	.....	...	.....	.....	.....	Thru a misunderstanding, this entire field test was plowed out early in 1922.
1918	McBryde Sugar Co...	3	No	3248	1337	2	281	1st	31–37	Plant	Promising.
1918	Hawaiian Sugar Co..	3	No	4200	594	2	113	1st	35	Plant	Promising.
1918	Grove Farm Co., Ltd.	1	No	1000	....	.....	9	1st	.....	.....	Not promising.
1919	McBryde Sugar Co...	1	No	2592	237	1	...	.....	.....	.....	Plantation cut for replant seed last July.
1919	Hawaiian Sugar Co..	1	No	4703	632	1	...	.....	.....	.....	
1919	Lihue Plantation Co..	..	No	3895	231	1	...	.....	.....	.....	Plantation plowed out this field test—Seedlings were not very promising.
1919	Grove Farm Co., Ltd..	1	No	1009	93	2	...	.....	.....	.....	Not promising—will watch ratoons.
1919	Kilauea Sug. Pl. Co..	1	No	650	17	.....	17	1st	.....	.....	Only fair.
1920	McBryde Sugar Co...	1	No	15686	2566	1st	...	.....	.....	.....	Weighed and sampled in January, 1923.
1920	Hawaiian Sugar Co..	1	No	2221	403	1st	...	.....	.....	.....	Weighed and sampled in June, 1923.
1920	Koloa Sugar Co......	3	Yes	1582	181	1st	21	.....	10	Plant	Promising
1920	Lihue Plantation Co..	..	No	1124	263	.....	...	.....	.....	.....	Plowed up by Plantation.
1920	Makee Sugar Co.....	1	No	3794	840	1st	...	.....	.....	.....	Weighed and sampled in February, 1923. Look good.
1921	Hawaiian Sugar Co..	2	Yes	148	17	Plant	...	.....	.....	.....	Only fair.
1922	Hawaiian Sugar Co..	2	Yes	263	36	Plant	...	.....	.....	.....	Promising as young canes.
	Grand Total			47023	7750						
	Less seedlings plowed up.............			5927	797						
	Total			41096	6953		424		153		

Spend to Save*

Many power plants will not stand even a casual inspection. They operate as evidence that somewhere along the line of ownership and management there is a lack of understanding of the savings that can be made through the expenditure of moderate sums for first grade supplies and time saving equipment.

Cracks in boiler settings, warped fire doors, inoperative dampers, steam and water leaks are proof that indifference or neglect prevails. The problem is to find those responsible for these conditions and then drive home the facts in each case.

Plants as pictured above do not generally exist because the engineer on the job is negligent or ignorant; for invariably it will be found that his actions indicate that he is physically fit, his clothes show that he is the kind of man who gets right into the job and a brief conversation will prove that he is experienced and knows his business.

Where, then, can the responsibility be placed? In any number of cases it is the fault of the management because the engineer, always a busy man, is not provided with first grade supplies and time saving equipment and instruments. The engineer is too often spending much of his time in a fight to keep the plant operating at any cost rather than exercising his ability to improve general conditions and the economy of the plant. His job is made one of physical endurance rather than that of capitalizing for his employer through the use of his experience and brains.

Such equipment as feed water regulators, flow and temperature records are time savers for the engineer. Packing and general supplies should not be purchased through the office on price considerations only. Consult the engineer and profit by his experience, for in this way the cost of supplies will be reduced; many hours can be saved both on maintenance and operation, with the result that the engineer will have time to study and effect worth-while economies.

You can profitably spend to save.

[W. E. S.]

* Power Plant Engineering, Vol. XXVII, No. 14.

India Improving Cane Varieties Through Seedling Canes*

The results of mill trials on selected seedling canes in India, carried out by Mr. Wynne Sayer, Secretary of the Sugar Bureau, are given in the Agricultural Journal of India, May, 1923.

The seedlings which gave the most promising results were crossbred at the cane breeding station, Coimbatore, which was instituted by the Government of India about ten years ago. Three of the seedling canes originated by the station have had practical tryouts, and show their adaptability to conditions in Northern India, particularly in North Bihar, which has a large number of cane growers, and in which district a number of modern factories manufacturing white sugar are located.

Cane varieties adaptable to this district require unusual hardiness, as the cultivator of North India gives his cane indifferent treatment, and as a rule has not sufficient funds to expend on fertilization. Some seasons in this vicinity are most trying, and it is necessary for the canes not only to be resistant to drought, but to withstand intense heat, which frequently prevails in this district. Three of the seedlings were selected, showing desirable qualities, known as Co. 210, Co. 213 and Co. 214.

These varieties prove to be good drought resisters, and their behavior during the growing season is splendid. The hot weather in 1922 was very severe, a temperature of 110 degrees Fahrenheit was experienced on several days with high wind, but during this hot weather Co. 213 showed no ill effect; Co. 214 and 210 also stood it remarkably well.

After the rain these canes made rapid progress, and their superiority over the local canes was asserted early. These canes have a hard outer rind and are not subject to damage from fungus or insect pests to the extent of the damage from this source in native canes.

Mill trials of these three varieties were successful, showing larger yields in the field and increased yields in the factory over local canes.

By combining these varieties with local cane, the grinding season can be started earlier, which will be of marked advantage in extending the operations of the mills. These hardy and resisting varieties promise to be of marked value to the Indian sugar industry, and show the benefit of intelligent scientific treatment as now being applied in India to its sugar industry.

[J. A. V.]

* From the Louisiana Planter and Sugar Manufacturer, Vol. LXXI, No. 4.

Formosa Sugar Industry*

The sugar industry in Formosa, which according to the original program of the Taiwan government, was aimed to reach a production of raw sugar at least sufficient to supply the demands of Japan, received a great setback as a result of serious typhoons in 1911 and 1912. This caused great fear for the future of the sugar industry.

The Far Eastern Review in reporting these conditions, states that by the results of carefully carried out experiments and substituting for the Rose Bamboo cane,—which had proved adaptable to Formosa conditions and produced a high percentage of sugar, but was susceptible to damage from winds,—a type of cane which resisted the winds, these difficulties are now obviated. Seedling canes were imported from Java, which proved of sufficient resistance to wind damage and adaptable to Formosa conditions, to largely replace the Rose Bamboo cane. In 1918, 35 per cent of the area under cultivation was of this Java cane, and in 1922 this percentage had been increased to 87.7 per cent. Following the marked benefits derived from the Java seedlings, Dr. Ishida, Chief of the Sugar Division of the Central Research Laboratory, developed native seedling canes from the Java seedlings, one of these called F-19, has proved to have high wind resistance power, and is shown in experimental cultivation to yield more sugar than the Java cane. The success of this variety has led Formosa to greater developments with hopes of further improvement along this line.

Coincident with the improvement in the cane has been improvement in the agriculture of the island, particularly relative to the tenant-farmer system. The older methods of restricting tenancy of the farmer to one year resulted in extensive cultural methods. The government has now reformed these old regulations so that the tenant will have possession for a minimum of six years, this has resulted in a marked improvement of the fields by fertilizing and deep plowing. The farmers have exerted themselves to increase production and the yields have increased from 1913 to 1921 almost 250 per cent, with prospects of further increase.

Leading sugar companies are now applying new regulations encouraging early planting and selection of varieties, with the result of the increased yields above mentioned, and the cane grown stands the ill effect of wind and rain storms better than the previous varieties planted in that country.

The sugar expert of the government looks forward to doubling the present production in the next ten years, and predicts an increase, by the judicious selection of seed cane of 20 per cent; by scientific fertilization, 50 per cent; by irrigation and drainage, 20 per cent; and by control of insect pests, 10 per cent.

Recent results by the Research Laboratory have established the economic limit of fertilization, giving formulas for same, and the government is planning the construction of large reservoirs for irrigation purposes, which when completed will make possible the irrigation of large areas of upland, at present without a supply of irrigation water.

With the cooperation of the companies and the government, it is expected that the sugar industry will be firmly established on a new and sounder basis.

[J. A. V.]

*From "The Louisiana Planter and Sugar Manufacturer, Vol. LXXI, No. 4.

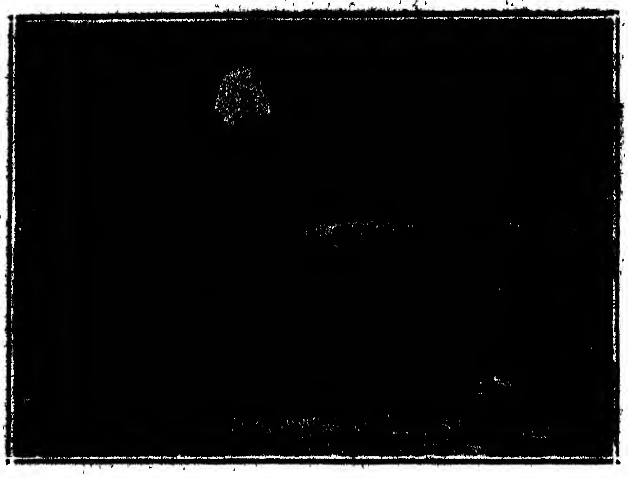
Plantation Notes—Illustrated

(Photographs by J. S. B. Pratt, Jr.)

Hitch used at Makee. Front doubletrees are eliminated, animals turning easier, and starting off quicker—for hauling cane, harrowing, etc.

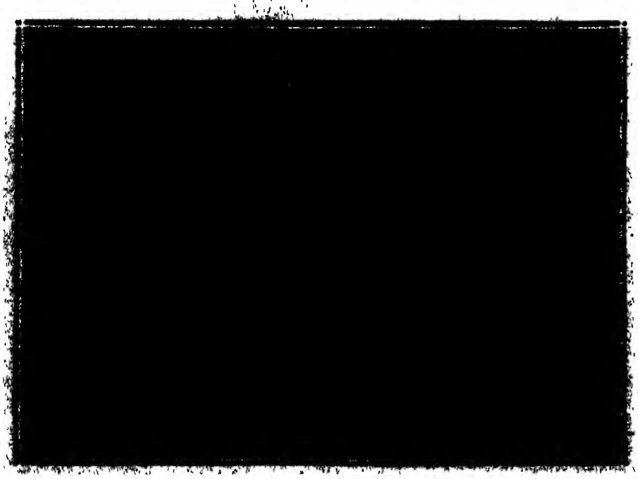
Broadbent sled for planting under unirrigated conditions, or for orchard system—front view.

Same as above — rear view. Two rows are planted. Note seat for boy while dropping seed.

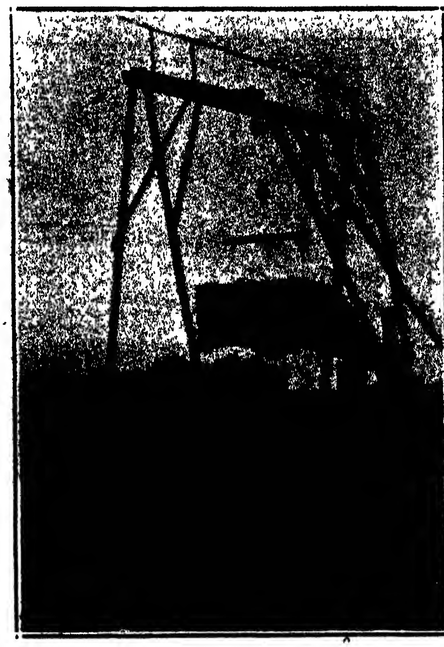


Outlet of 1100 ft. syphon installed by Kilauea Sugar Plantation.

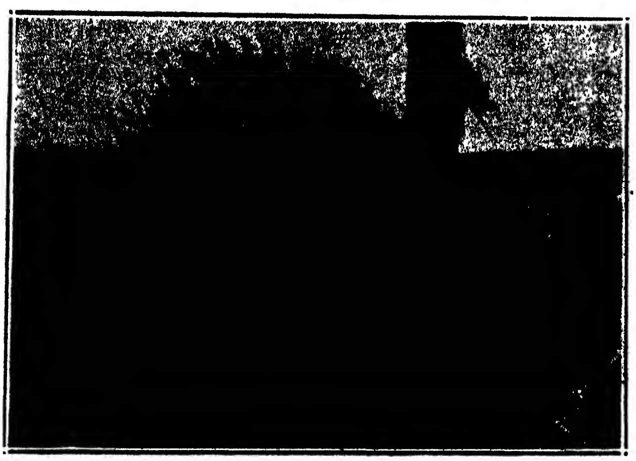
Kiliffer Subsoiler used at Kaiwiki Sugar Co.



Harrow used in grading portable track beds at Kilauea.

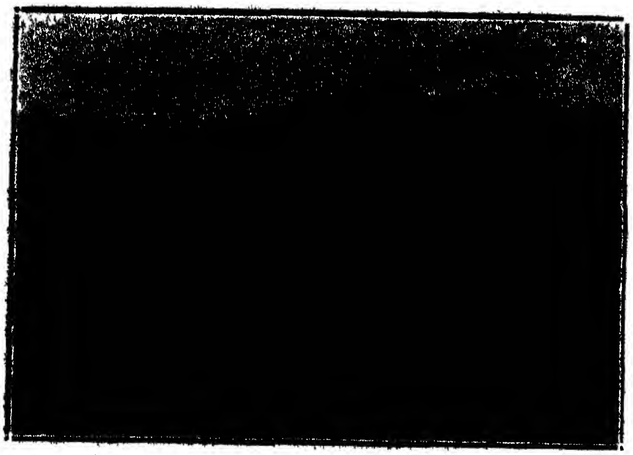


Loading station at Hamakua Mill Co. Lifting load from wagon to cars.

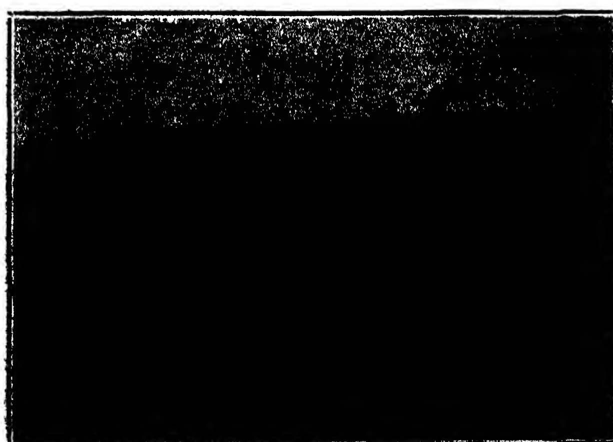


Uba cane grown without attention at Kilauea by roadside, instead of weeds and lantana.

Badila (left) and Uba (right) at Kilauea.

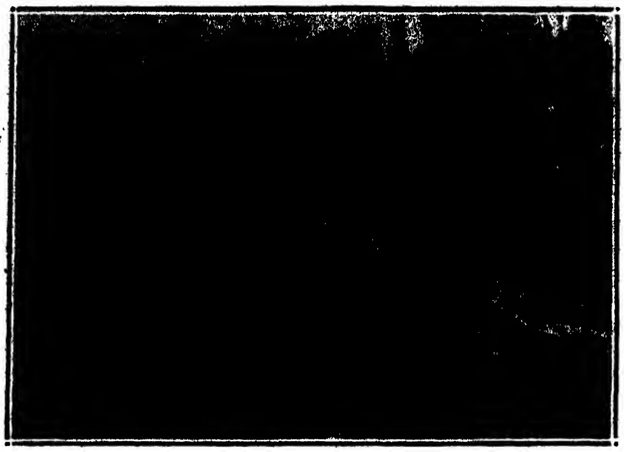


Nine weeks old Yellow Tip ratoons at Makee. Seed of this variety was desired for mauka lands, so a few bags received from Pioneer were planted under the best conditions makai, cutting 15 to 1 in 8 months. Mgr. Wolters in picture.



Sled seen on Hawaii. Used to haul cane to flume from long packs.

Movable shed at Onomea to lock up gasoline in field for tractors. Could be used to store fertilizer in field.



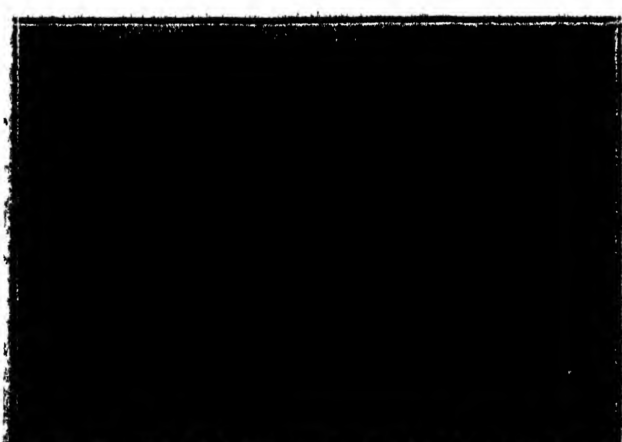
Type of packsaddle seen on several plantations. This one at Makee.

Applying mudpress in the furrow to ratoons.

Geri-geri implement used to break lumps in furrow before planting at Hilo Sugar Co.

Soaking seed at Koloa. Cars with seed are quickly run in on track placed in pond. Pieces of portable track put on top of seed to keep bags from floating.

Soaking seed at Kilauea. Much handling of seed is saved.



Riding disk cultivator at Kilauea.

Sugar Prices.

95° Centrifugals for the Period June 19 to September 15, 1923.

Date	Per Pound	Per Ton	Remarks
June 19, 1923....	6.905	$138.10	Cubas, 7.03, 6.78.
" 20	7.095	141.90	Cubas, 7.03; Philippines, 7.16.
" 21	7.28	145.60	Cubas.
" 22	7.53	150.60	Cubas.
" 27	7.16	143.20	Spot Cubas.
July 9	6.91	138.20	Cubas.
" 11	6.655	133.10	Philippines, 6.53; Cubas, 6.78.
" 13	6.78	135.60	Porto Ricos.
" 16	7.155	143.10	Cubas, Porto Ricos, 7.03; Cubas, Philippines, 7.28.
" 18	7.03	140.60	Porto Ricos.
" 20	6.91	138.20	Philippines.
" 25	7.00	140.00	Cubas, 6.97, 7.03.
" 27	6.91	138.20	Cubas.
Aug. 6	6.15	123.00	Cubas.
" 14	6.09	121.80	Philippines, 6.03, 6.15.
" 15	5.90	118.00	Cubas.
" 16	5.78	115.60	Cubas.
" 17	5.795	115.90	Porto Ricos, 5.81, 5.78.
" 20	5.78	115.60	Philippines.
" 21	5.81	116.20	Cubas.
" 23	5.825	116.50	Cubas, 5.84, 5.81.
" 24	5.90	118.00	Porto Ricos.
" 27	6.0675	121.35	Porto Ricos, 6.00; Cubas, 6.03, 6.09, 6.15.
" 28	6.09	121.80	Cubas, 6.15, 6.03.
" 29	6.15	123.00	Cubas.
" 31	6.2167	124.33	Cubas, 6.15, 6.28; Philippines, 6.22.
Sept. 5	6.28	125.60	Porto Ricos.
" 10	6.465	129.30	Cubas, 6.40, 6.53.
" 11	6.65	133.00	Cubas.
" 12	6.75	135.00	Cubas, 6.72, 6.78.